MARCH 6, 1961
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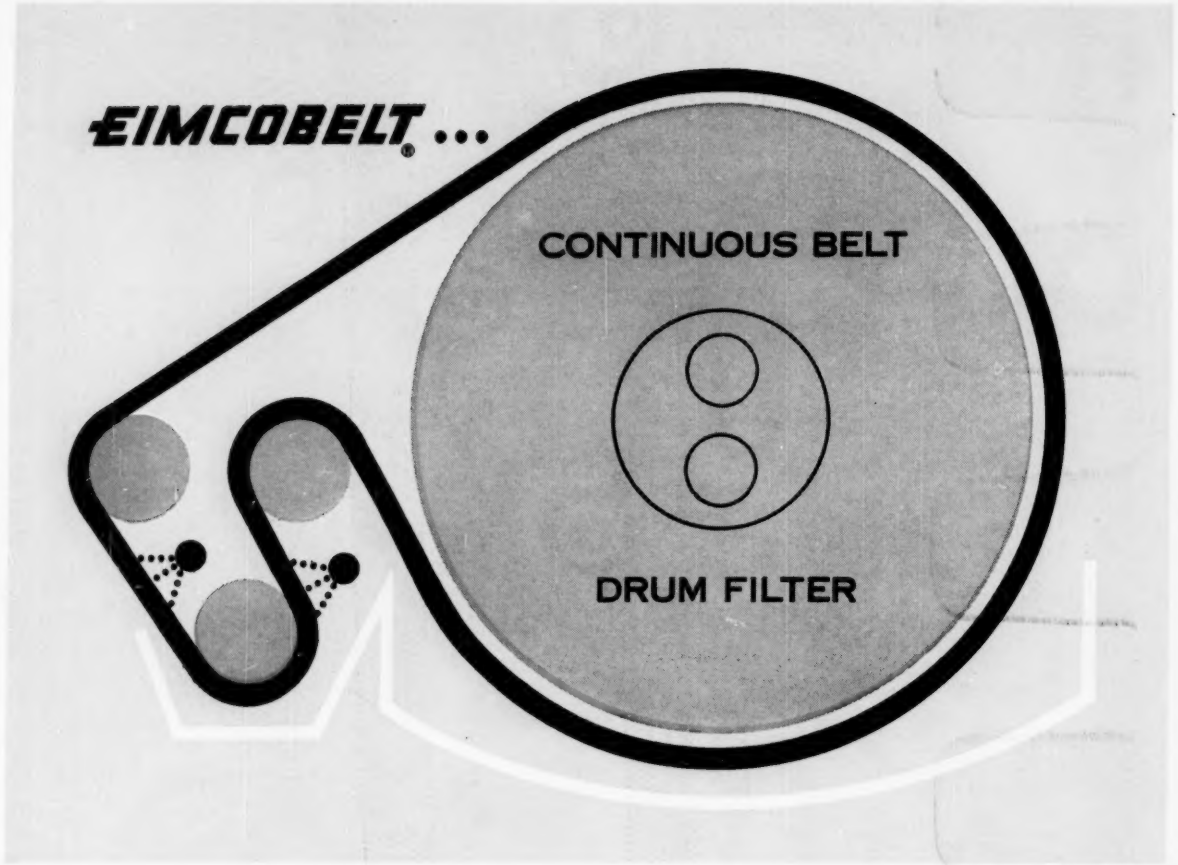
Chemical Engineering

A McGRAW-HILL PUBLICATION



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. . . Continuously, and with no fall-off in filtration rate caused by progressive blinding

Because EimcoBelt filters remove the belt filter medium from the drum for cake discharge and cloth washing, continuous filtration of a wide range of difficult slurries is now possible. The filter medium is scoured clean with wash sprays, front and back, before it is returned to the drum. Blinding is eliminated. EimcoBelt filters now in operation are saving processors thousands of dollars a day filtering glutinuous slurries . . . slurries low in solids concentrations . . . slurries that have always been considered too troublesome for continuous filtration. Ask the Eimco representative in your area how EimcoBelt filters can save processing dollars in your plant. Write Eimco Filter Division for Bulletin F-2053.

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Hoseful of hot stuff

How an improved kind of hose makes acid handling safe

IT'S only a few feet from truck to storage tank. But it used to be a most expensive short haul for cargoes of highly corrosive acid. The acid is so strong and powerful it would chew through ordinary rubber hose in no time. Metal tubing couldn't take sharp angles or stand much bending.

Then a B.F.Goodrich distributor told the company about a new hose that had been developed by B.F.Goodrich. This hose was lined with a special new rubber compound made to defy even the most corrosive acids and chemicals.

The hose above is made of this new material. It has already lasted several times as long as regular hose and the end is nowhere in sight. And there have been no costly and dangerous acid leaks. What's more, workmen claim this new hose is lighter, easier to handle because it's more flexible, faster to hook up because of special attachments at the hose ends.

Your B.F.Goodrich distributor has complete information on the new B.F.Goodrich acid hose described here. And, as a factory-trained specialist in rubber products, he can answer your questions about *all* the rubber products B.F.Goodrich makes for industry. *B.F.Goodrich Industrial Products Company, Dept. M-975, Akron 18, Ohio.*

B.F.Goodrich

ACID HOSE

This phone conversation actually took place when the chief engineer of one division of a large chemical company called his opposite number in another division to check the Birds performance record before placing an order.

The "forgotten" Birds are running 24 hours a day, 7 days a week. Each handles 500 gpm of a heavy slurry containing somewhat abrasive solids. An average of 250,000 tons of solids are dewatered before the conveyor facing is renewed. Between times, routine lubrication was all they needed. No wonder the "chief" had dismissed them from his mind.

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Chemical Engineering

March 6, 1961

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

PRINT ORDER FOR THIS ISSUE 53,032

WHAT'S HAPPENING

OTHER REGULAR FEATURES

ENGINEERING PRACTICE

VOLUME 68, NUMBER 5

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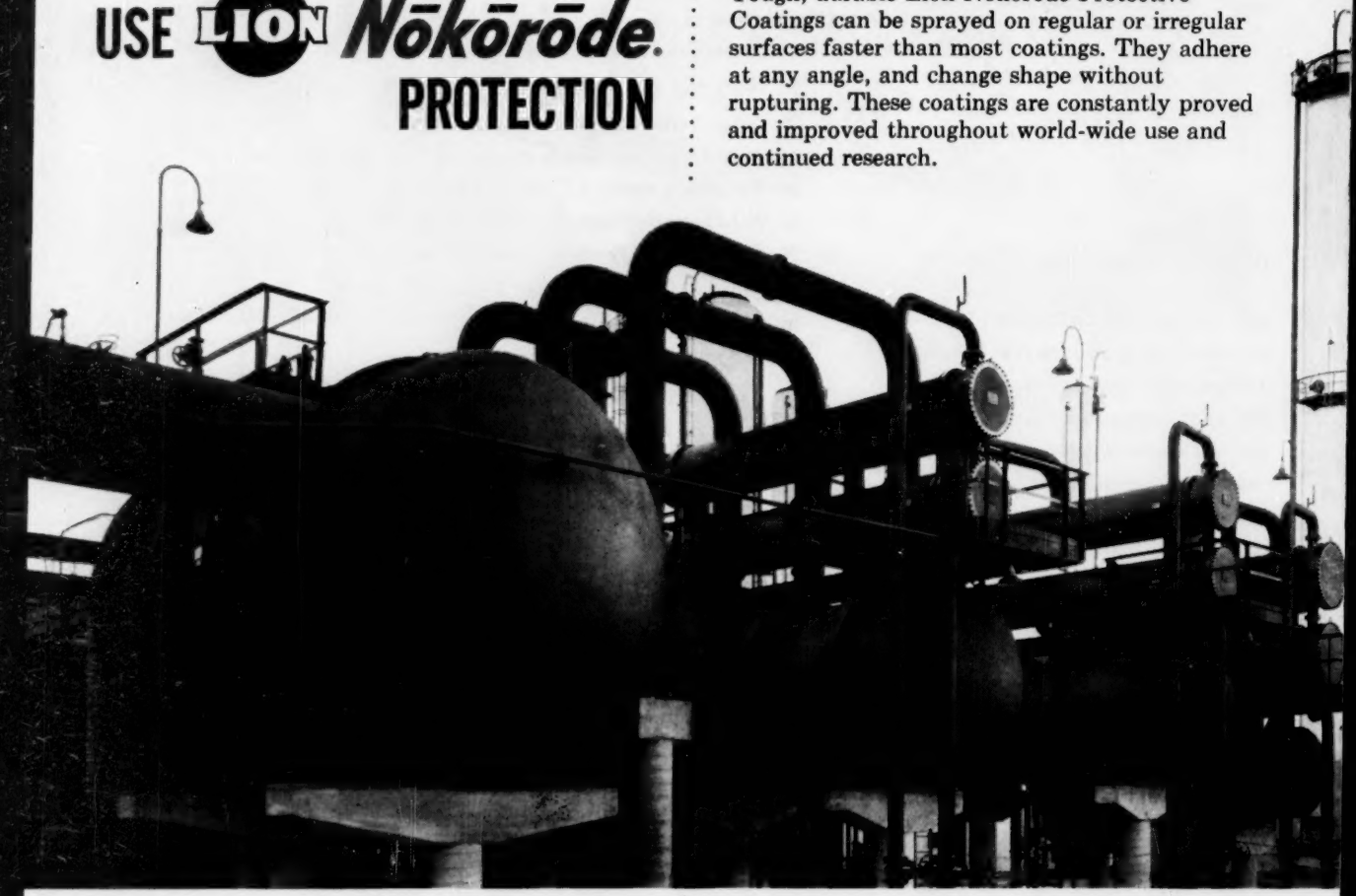

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Chemical Engineering
MARCH 6, 1961

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highlights of this issue

CHEMICAL ROCKET-PROPULSION SYSTEMS

Recent developments in chemical propulsion are opening up a big new field for employment of chemical engineers and consumption of chemical products. Whether or not you're directly involved, you'll want to keep up with what's happening in this fast-moving industry. Author of this Feature Report (p. 99) is Aerojet-General's F. J. Hendel, who heads up a team working on new fuels and oxidizers.

HOW TO IMPROVE THE MEETINGS YOU RUN

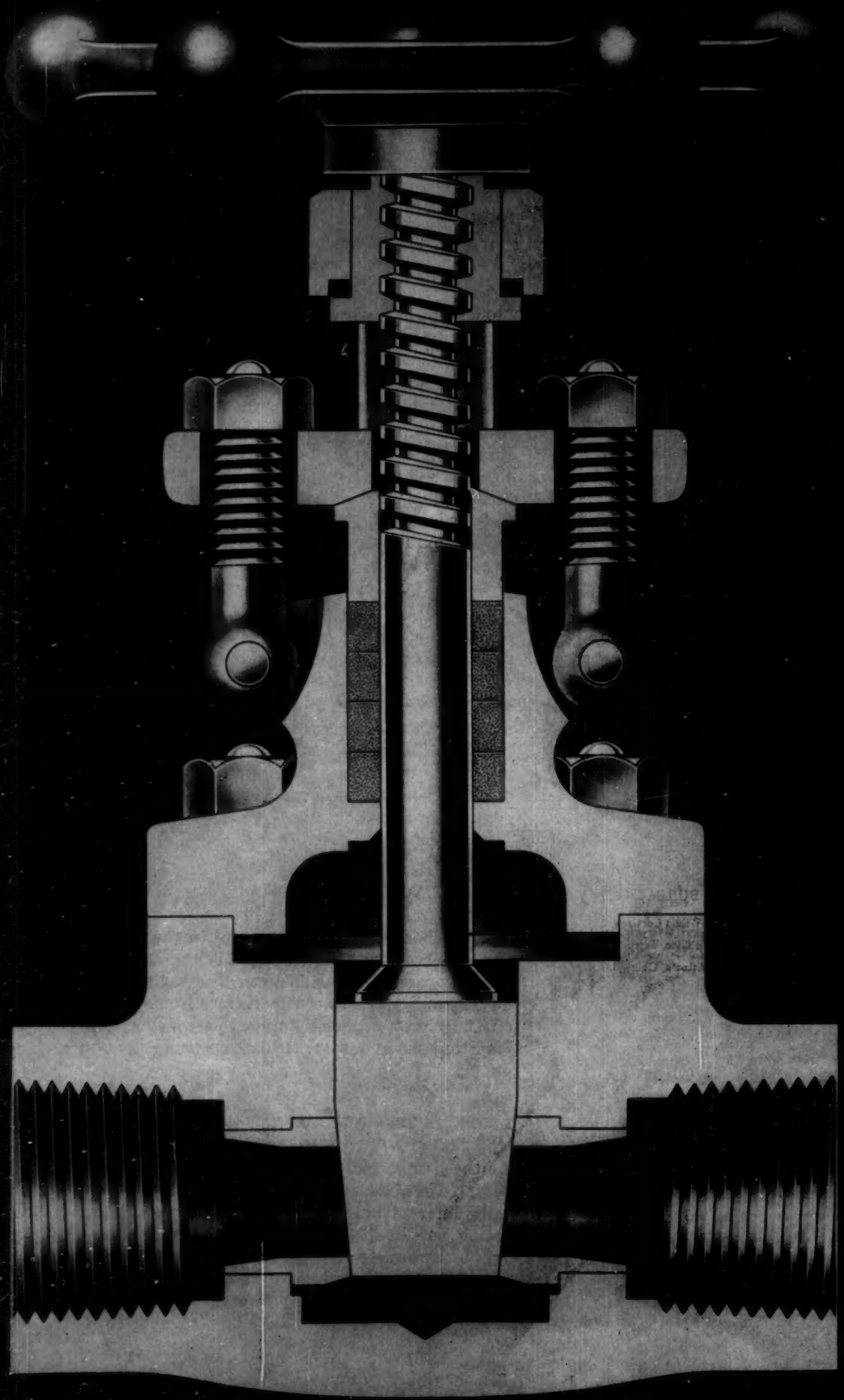
Whether you're a junior engineer or company president, you undoubtedly spend many hours in meetings. If you are leading the discussion, it's your responsibility to keep the meeting on the track. Lynn Surles and Walt Stanbury, authors of a new book, "The Art of Persuasive Talking," give some pointers in You & Your Job (p. 128).

EVALUATING QUANTITY DISCOUNTS

The "giant economy size" may not be the most economical, as pointed out in this article (p. 117) by chemist-economist-plant manager G. E. Mapstone. The savings you get from large-quantity orders of raw materials and supplies may be offset by cost of added storage space and inventories. Dr. Mapstone shows how to calculate optimum size of order.

EXOTIC LUBES ANTICIPATE SPACE DEMANDS

As the jet age spawned development of new chemical lubricants (e.g., esterlubes), so does the space age require radically different kinds of materials and techniques for lubricating satellites and other space craft. For this article (p. 59), Associate Editor Frances Arne assembled the most significant ideas, chemically speaking, from a recent Southwest Research Institute conference.



The reputation of a valve is made by the plants it keeps on stream

A valve is often looked upon as a "supply item" until it prevents a major process shutdown and profit loss...

Hancock Steel Valves provide the dependable protection demanded for every process application today and tomorrow. They are available in a wide range of operational pressures and temperatures . . . in an extensive selection of alternate trim, body, and bonnet materials to match the toughest services. They have that extra measure of quality that only a leader knows how to build into a valve... extra quality that extends the operating period between turnarounds and assures efficient, economical processing of petroleum and chemical products.

The valve illustrated at the left is the Hancock Type 950 Steel Gate Valve widely used by the processing and power industries.

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Dodge has supplied mounted bearings to industry for over three-quarters of a century. Dodge bearings have always kept pace with improved production practices. Each new condition of service has been met by Dodge as it has arisen, with the result that the Dodge line contains mounted bearings to meet almost every service requirement with pinpoint accuracy.

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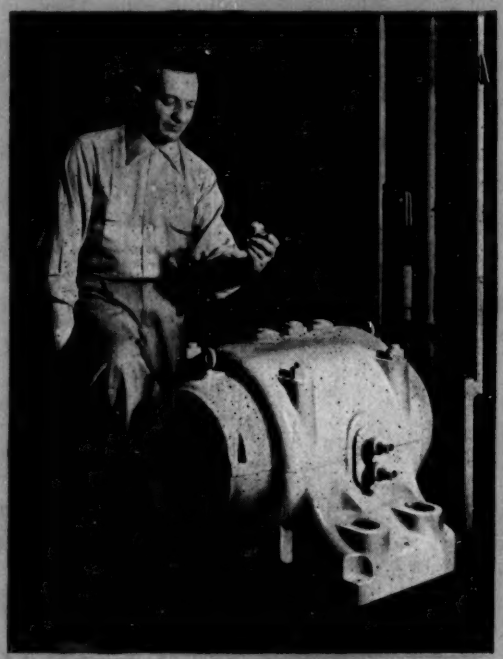
In the great variety of mounted bearings developed by Dodge, you will most likely find the precise unit to fit your requirements ideally—without paying for features you do not need. And if your requirements call for several types of bearings, there is an advantage in having them of common design, such as Dodge offers.

The Dodge line is probably broader than any other line of mounted bearings in America. And of special importance to machinery manufacturers, it is the most widely distributed line. There is always a Dodge bearing of the right type and size near at hand.

You can check this with your local Dodge Distributor. Ask him—or write us for the Dodge Bearing Bulletin.



In addition to tapered roller, spherical roller and ball bearings, Dodge builds many types of sleeve bearings. Here is the "large and small" of the sleeve type bearings carried in stock—ranging from an 8-in. Sleevoil weighing over 1200 lbs. to a ½-in. solid journal bearing weighing 9 ounces.

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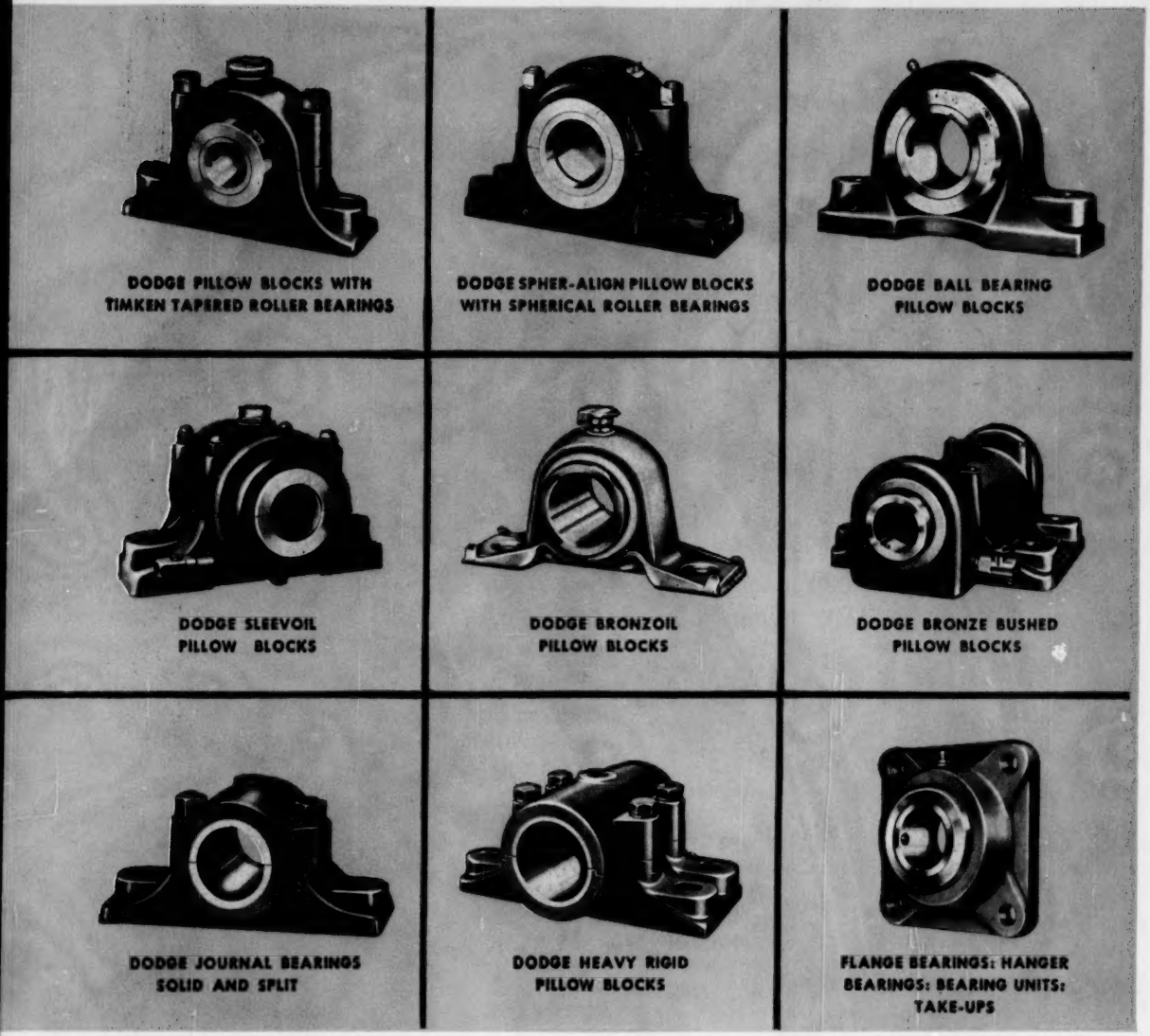

● **Dodge Pillow Blocks with Timken Tapered Roller Bearings.** America's quality pillow blocks. Assembled, lubricated, adjusted and sealed at the factory. 5 types for varying needs.

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● **Dodge Bronzoil Pillow Blocks.** Efficient, low cost pillow blocks with self-oiling, capillary bronze bushings. Self-aligning. Large oil reservoirs.

● **Dodge Bronze Bushed Pillow Blocks.** Quiet fan and blower pillow blocks with two bronze bushings of high lead content mounted in one cast iron housing.

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CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

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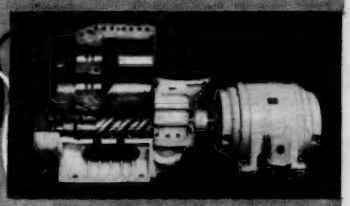

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FAIRBANKS-MORSE leadership shows again...with an advanced European concept to produce a truly unique aid-to-industry...our proved **AXIAL FLOW ROTARY COMPRESSOR** with Helical-shaped rotors! No reciprocating parts! No valves! No metal-to-metal contact provides maximum reliability...with high efficiency...at minimum costs!

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  Smooth, economical compression with OIL-FREE delivery!
- **DEVELOPED IN SWEDEN! PROVED IN EUROPE! WIDELY USED IN U.S.A.!**
  Now—Fairbanks-Morse is in full production on our revolutionary Rotary Compressor . . . at our large Beloit, Wisconsin plant. The leaders of AMERICAN industry now use our Rotary Compressor . . . with PROVED results!
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Our new Compressor is your logical choice for a wide variety of applications:

- Chemical and petrochemical process industries • Refinery process industries
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- Many other general purpose industrial and process uses.

Discover How The New F-M Rotary Compressor Can Step Up The Efficiency of YOUR Operations and Cut Down Maintenance Costs: Send for your copy of the New Fairbanks-Morse Compressor Bulletin Number ACO100.4.

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Control Valves

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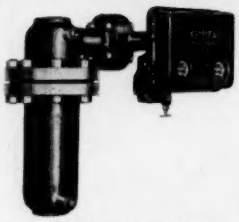
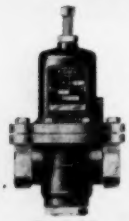
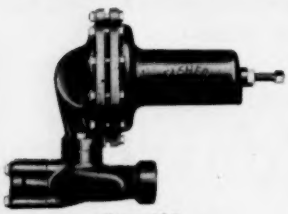


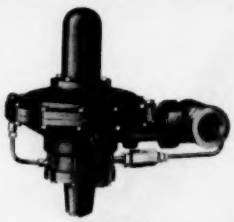
Series 2500–249 and 259B
Level-Trols—Cage Sizes 14" & 32"



Type 95
Pressure Reducing Valve



Type 630
"Big Joe" Field Regulator



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Multi-Purpose Gas Regulator

Call Fisher for 36-hour Service

Write, wire, phone or TWX for "supermarket" service direct from factory or factory-trained engineers in these strategically located offices:

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An Example of Fisher "Supermarket" Service . . .

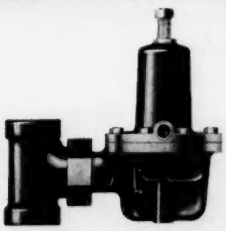
It was on a Friday morning when the Fisher representative in Oslo, Norway, called the plant in Marshalltown with an emergency order. Selection was made from the Fisher "Supermarket" stock and shipped immediately. The control was actually in the customer's plant in Oslo on the following Monday.

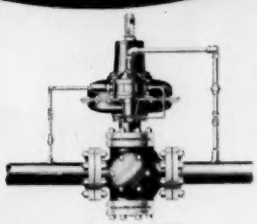
Fisher Governor Company, Marshalltown, Ia.
Plants in Woodstock, Ont., Rochester, England. Butterfly Valve Div.: Continental Equipment Co., Coraopolis, Pa.

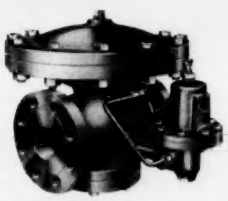
If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER®
SINCE 1880


Series 470
P.O.P. Control Valves


Series 620 and 621
Farm Tap Regulators


Series 298T
Gas Regulators


Type 92B Pilot Operated
Steam Reducing Valve


Type 655-A
Pressure Regulator

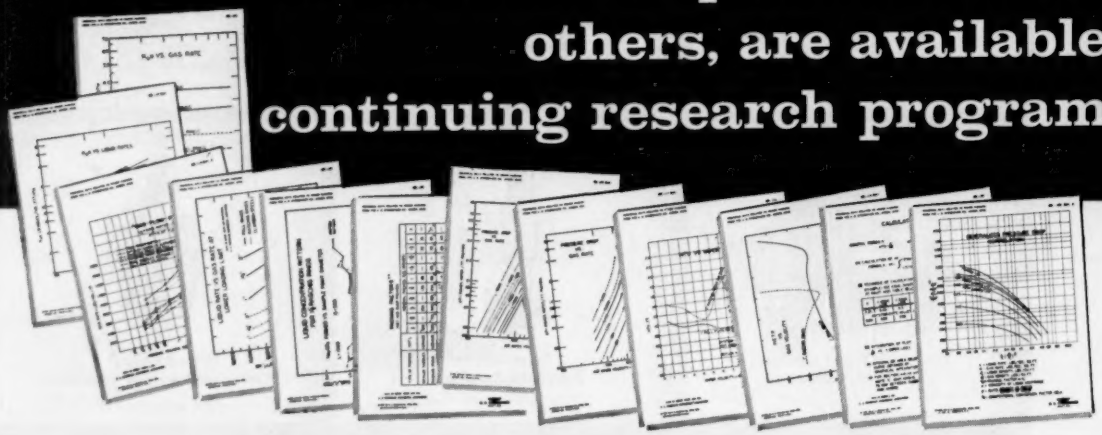

Series 67FR
Combination Filter Regulator

"We are operating at a reflux ratio of 1:1 with a vapor velocity of 4 feet per second. The system is acetone and water. Packed depth is 30' of porcelain raschig rings. How many more transfer units can I get if I switch from 1" raschig rings to Intalox saddles?"

"We have to install an additional scrubber. Our existing fan is good for 7000 cfm with a static pressure rating of 6" of water. The sum of the up-stream and down-stream pressure drops is 3 1/2" of water. We'll be circulating 60 gal. per minute caustic soda solution. Can this fan handle 7000 cfm in a 36" column packed to 25' with 1" rings?"

"I have the problem of reducing the CO_2 content of 20,000 lbs. of air per hour from 1% to less than 1/10 of 1%. Air temperature is 100°F at a pressure of 1 atm. 10% caustic soda is available. What size tower will I require if I pack it with raschig rings? With Intalox saddles?"

The answers to questions such others, are available continuing research program



363-G

"We have a 6' dia. column with 27 bubble cap trays on 18" spacing. It's used to remove CO_2 from ammonia synthesis gas. Solvent is a 15% mono-ethanolamine solution. Can we modify this tower to get a 35% increase in gas treating capacity?"

"We are packing an 8' 6" dia. column with 32 feet of 2" Intalox saddles. The tower will operate at 90 psia. Gas rate 225,000 lbs./per hr. Liquid rate 550,000 lbs./hr. (Sp. gr. of unity). How often should we redistribute? What type of distributor and redistributor should we use? Will we flood at the support plate? What can we do to minimize breaking of the packing if surges occur?"

"Our current vacuum distillation of a highly heat sensitive specialty organic compound is resulting in excessive pyrolysis of a costly product. We operate our still with 5 mm Hg. at the condenser and 30 mm in the pot. We're using 1" stainless steel raschig rings. Would it help to switch to 1" metal Pall Rings?"

as these, and to countless to chemical engineers through our on packed tower performance

If you are not on our mailing list to receive these releases on packed tower performance, please write, on your letterhead. Previous releases will be sent you immediately. Address Dept. CEP 361, The U. S. Stoneware Co., Akron 9, Ohio.

PROCESS EQUIPMENT DIVISION

U. S. STONEWARE

AKRON 9, OHIO

THE TURN OF ONE DIAL MATCHES PROCESS SPEEDS TO CHANGING PRODUCT DEMANDS

The value of the Reliance Super 'T' V★S Drive on this extruder is in its ability to produce and hold accurately the wide range of specific speeds necessary to handle a variety of plastic materials.

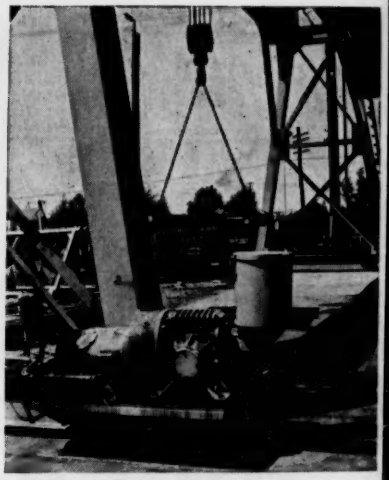
Polyethylene, polystyrene, nylon and PVC are among the plastics that are color-compounded, heated and extruded for pelletizing. Each one calls for a different machine speed and setting. Motor operating speeds can be varied from 145 to 2000 rpm . . . and within the range, the V★S Drive maintains the exact speeds needed to extrude and pelletize each type . . . and this even includes zero speeds for set-up.

These perfectly controlled speeds and the 24-hours-a-day, 7 days-a-week use demanded by this plant's production schedule are the basic reasons why Plastic Materials and Polymers, Inc. has standardized on Reliance V★S Drives in all three of its plants.

BUILDERS OF THE TOOLS OF AUTOMATION

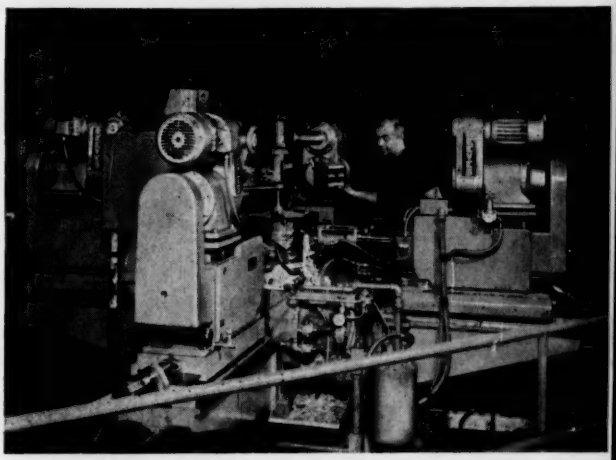
A-1683

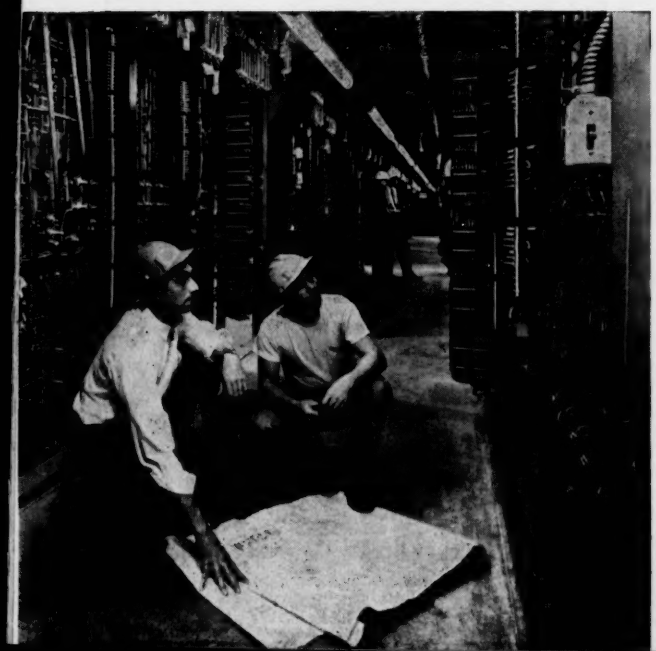
ONE SELF-CONTAINED, COMPACT POWER PACKAGE. This MASTER GEARMOTOR has been operating outdoors for 5 years regardless of weather. It has no exposed high speed couplings, no V-belts, chains or sprockets. Engineering and assembly costs are reduced. You can simplify installations and save space with vertical, horizontal and flange mountings; output shaft over, under, left or right. Ratings 1/8 to 125 hp. in right angle, parallel or in combination. Right angle ratios are available up to 96:1; parallel 120:1. Bulletin E-2409.



CONTOUR EPOXY-COATED TO ELIMINATE ENCAPSULATION CRACKING. New RELIANCE ENCAPSULATED MOTOR . . . gives you positive protection from dust, dirt, acid and water. Unlike other heavy molded coatings, stator windings are vacuum-impregnated with epoxy resin at a uniform thickness, follow the contour of the windings. You get maximum flexibility, tensile and bond strength, plus quicker cooling . . . all vital to superior motor performance. Bulletin B-2108.

INFINITELY VARIABLE OUTPUT SPEEDS AT LOW COST. REEVES MOTODRIVES, shown here powering this 4-position drilling and boring machine, are used extensively for hundreds of production needs. Horsepower ratings from ¼ to 40, speeds from 1.71 to 4660 rpm. Speed variation ranges from 2:1 to 10:1. Available in hundreds of space-saving assemblies . . . with manual, remote or automatic process control (Airtrol). Bulletin M-592.



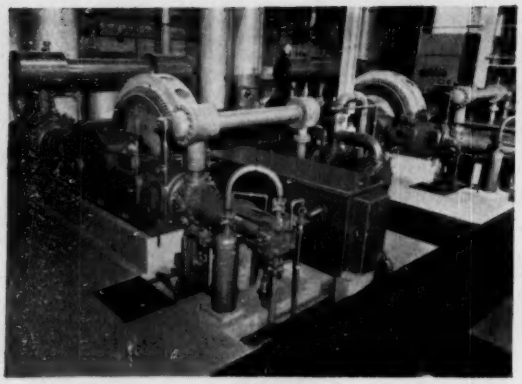


TOTAL SERVICE is an integral part of every Reliance product, from engineering and start-up assistance to maintenance and renewal parts. The photo shown here is typical of a Reliance Service Engineer's on-the-job availability—for maintenance and consultation on knotty problems. Every Reliance Sales Engineering Office and Distribution Center—nationwide—gives you the attention and experience necessary to assure the top performance you expect from the Reliance equipment you buy.

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT.133A, CLEVELAND 17, OHIO • Canadian Division: Toronto, Ont

HORIZONTAL

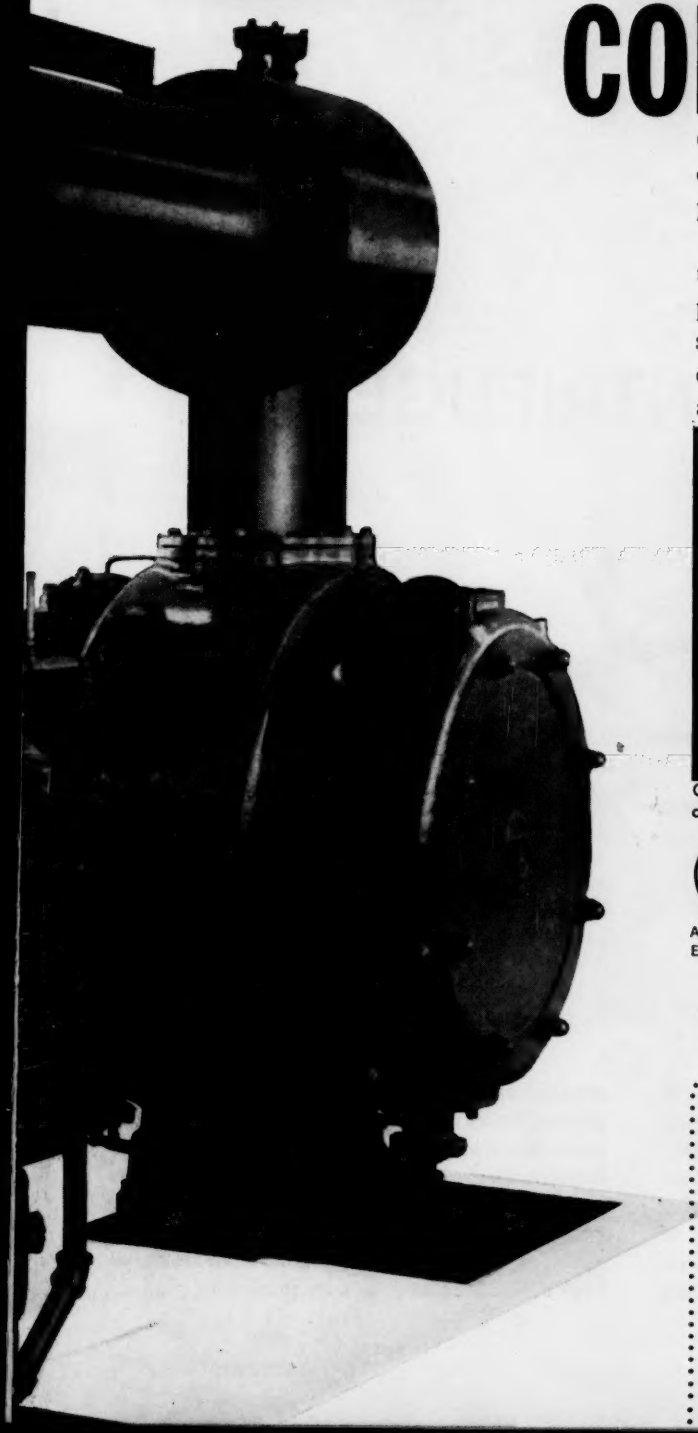


Class H-CE, 4-corner, 5-stage compressor
operating at 3,000 psig

A battery of these 800 hp Class O-CE Compressors serve a large steel mill

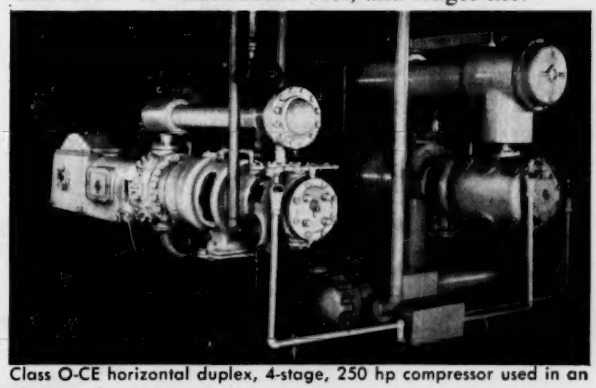
DUPLEX

LOW SPEED COMPRESSORS



Chicago Pneumatic offers a wide variety of designs of compressors in sizes up to 5,000 horsepower and for pressures up to 15,000 psig.

Horizontal machines such as the Class O Duplex and the Class H Horizontal Four-corner Compressor are preferred for many applications because of their low speeds, greater accessibility, greater flexibility of cylinder arrangements for many multi-stage installations, and for lower maintenance cost, and longer life.



Class O-CE horizontal duplex, 4-stage, 250 hp compressor used in an air separation process

Chicago Pneumatic

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC AND ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS

SEND THIS COUPON . . . Get Your Free Copy of "Compressor Specifications" Now!

Includes 14 pages of compressor engineering data, plus 2 special reports on reciprocating compressors.

Chicago Pneumatic Tool Company Dept. CE-11
8 East 44th Street, New York 17, N. Y.

Please send FREE copy of "Compressor Specifications" to:

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Company_____

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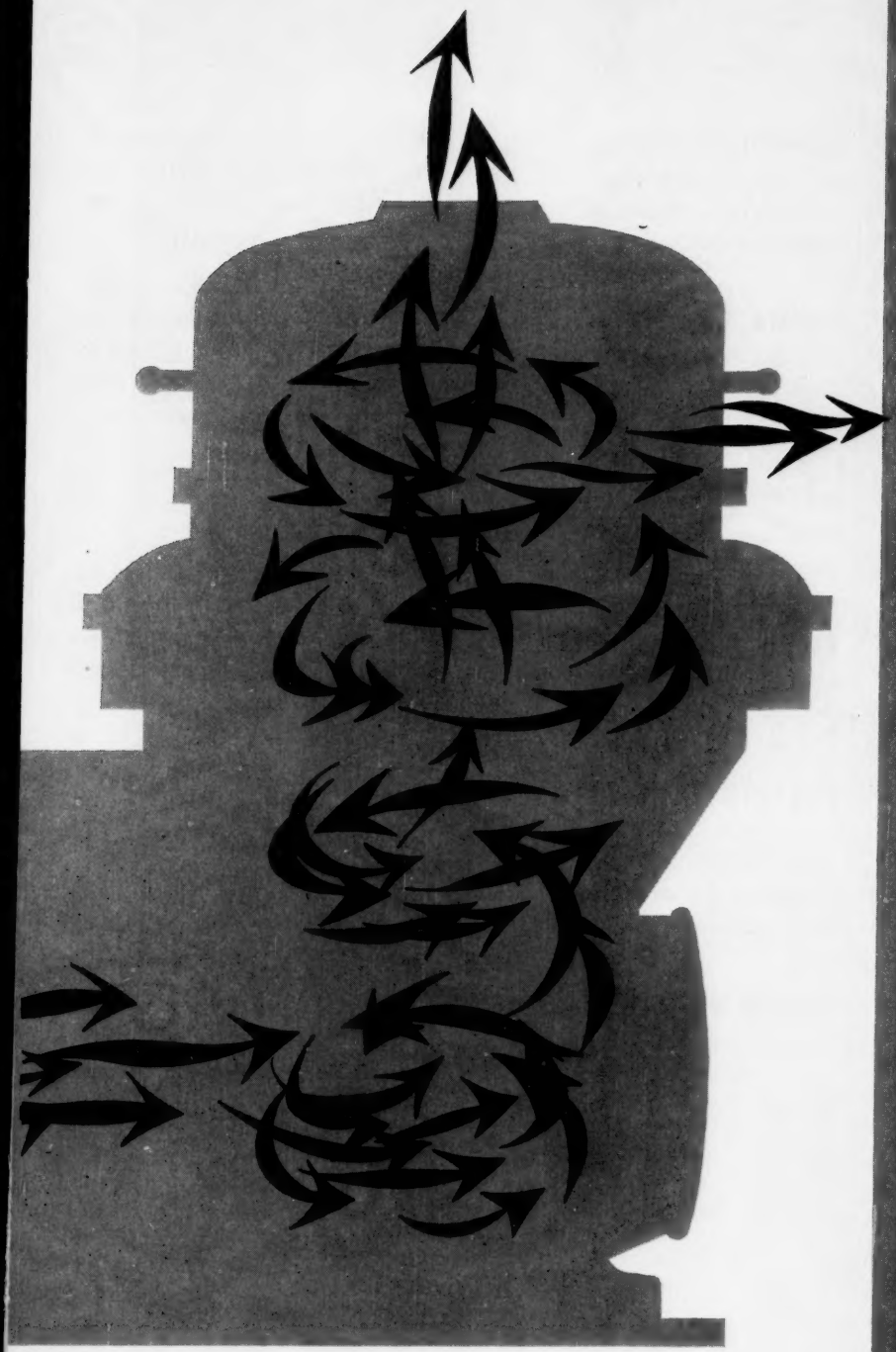
6000 G's give instant on-stream separation or clarification in

DE LAVAL PROCESS CENTRIFUGES

Modern on-stream separation of liquid-liquid phases is as simple as this: pipe the product mixture into the process centrifuge. It is instantly separated into its heavy and light phases, which are continuously discharged. Tremendous gravity forces are used to provide the wide range of liquid-liquid-solid separations described here. These separations are finding rapidly expanding applications in continuous-flow processing—replacing bulky settling tanks and batch filter systems. More important, De Laval Process Centrifuges perform separations of types and efficiencies not previously possible—opening up entirely new process potentials. Information on many such processing modernizations is available from De Laval.

A sound look at your own present or planned



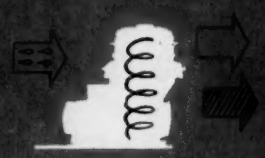
process by a De Laval engineer can quickly determine the process benefits and economies. Start by requesting our booklet on centrifuge types and their applications.

THE DE LAVAL SEPARATOR COMPANY

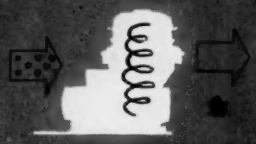
Poughkeepsie, N. Y.
5724 N. Pulaski, Chicago 46, Ill.
201 E. Millbrae Ave., Millbrae, Cal.

Dept. C-3.

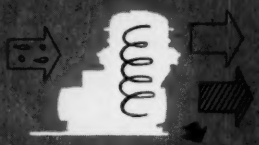
BASIC PROCESS APPLICATIONS:



LIQUID-LIQUID: Separations of immiscible liquids range from removing trace moisture in oils to high-flow-rate separation of reaction product mixtures. Volatile liquids can be processed under pressure.



LIQUID-SOLIDS: Suspended solids of any fineness are instantly removed to give crystal clear product streams. Sediment is removed periodically for disposal or recovery. When suspended solids represent a significant proportion of the product stream, the solids can be removed continuously and automatically by specially designed De Laval centrifuges.



LIQUID-LIQUID-SOLIDS: The removal of sediment or solids in no way affects or handicaps the separation of immiscible liquids where such 3-phase systems exist.

PROCESS DESIGN FACTORS: Materials of construction can be matched to operating conditions. Operating pressures up to 150 lbs. p.s.i. can be handled, permitting efficient processing of volatile and air sensitive materials. Capacities of De Laval's Process Centrifuges range from 2 to 12,000 gallons per hour—and the very largest requires only 12 sq. ft. of floor space.

INDUSTRIAL CHEMICALS

ANHYDROUS AMMONIA – This basic industrial chemical is available in commercial and refrigeration grades from three strategically located plants.

AQUA AMMONIA (NH_4OH) – An economical source of nitrogen and an easily handled alkali.

AMMONIUM NITRATE–In pelleted form. Typical analysis: Ammonium Nitrate content – 96% or more.

AMMONIUM NITRATE SOLUTIONS – NFS-83 and NFS-50. Ammonium nitrate-water solutions containing respectively 83% and 50% NH_4NO_3. For explosives, fluid catalysts, pharmaceutical applications.

AMMONIUM SULFATE – Diverse uses include fireproofing, fertilizers, leather tanning.

ETHYLENE OXIDE – Rocket propellant, fumigant, fungicide, chemical intermediate.

ETHYLENE GLYCOL – Also Di- and Tri-. Humectants, plasticizers, scrubbing solutions for gas dehydration, scores of other industrial uses.

ETHANOLAMINES – MEA, DEA, and TEA. Versatile, reactive, easy to handle. TEA available in 98% and commercial grades.

FORMALDEHYDE – Available as 37% Inhibited, 37% Low-Methanol, 45% Low-Methanol, 50% Low-Methanol.

METHANOL – 99.85% pure. In barge, tank car, and tank-truck quantities.

NITROGEN TETROXIDE – High energy oxidant for liquid rocket propellants. Easy to handle and store.

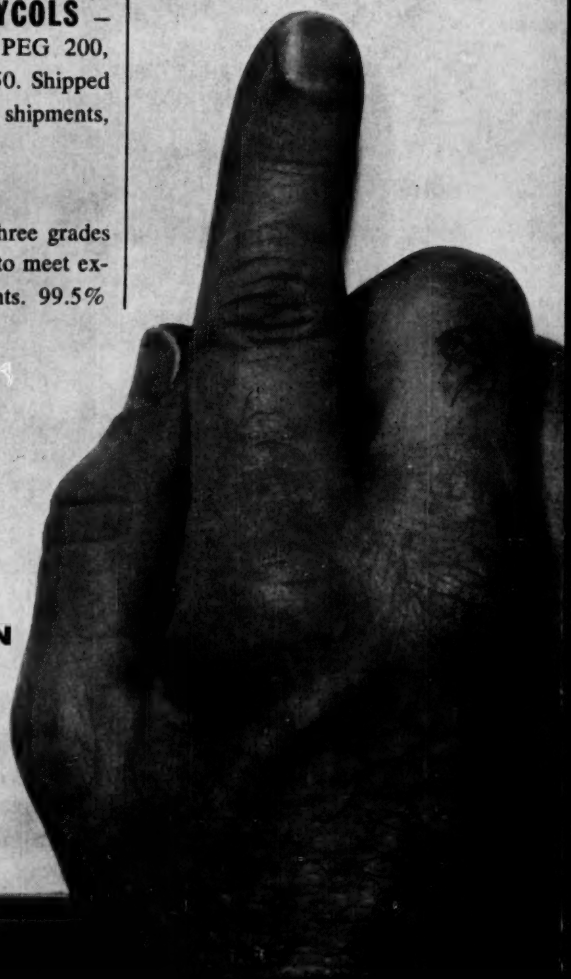
POLYETHYLENE GLYCOLS – Available in six forms: PEG 200, 300, 400, 600, 1000, 1450. Shipped in tank car or combination shipments, tankwagon and drums.

SODIUM NITRATE – Three grades – coarse, medium, fine – to meet exacting process requirements. 99.5% pure.

UREA – Multiplant production assures unfailing supply of this basic chemical in crystal and pelleted form.

U-F CONCENTRATE-85 – Highly concentrated solution of urea (25%) and formaldehyde (60%). Easy to handle, economical source of these materials for resins and adhesives.

For specifications and local offices, see our insert in Chemical Materials Catalog, page 272A and in Chemical Week Buyers Guide, page 27.

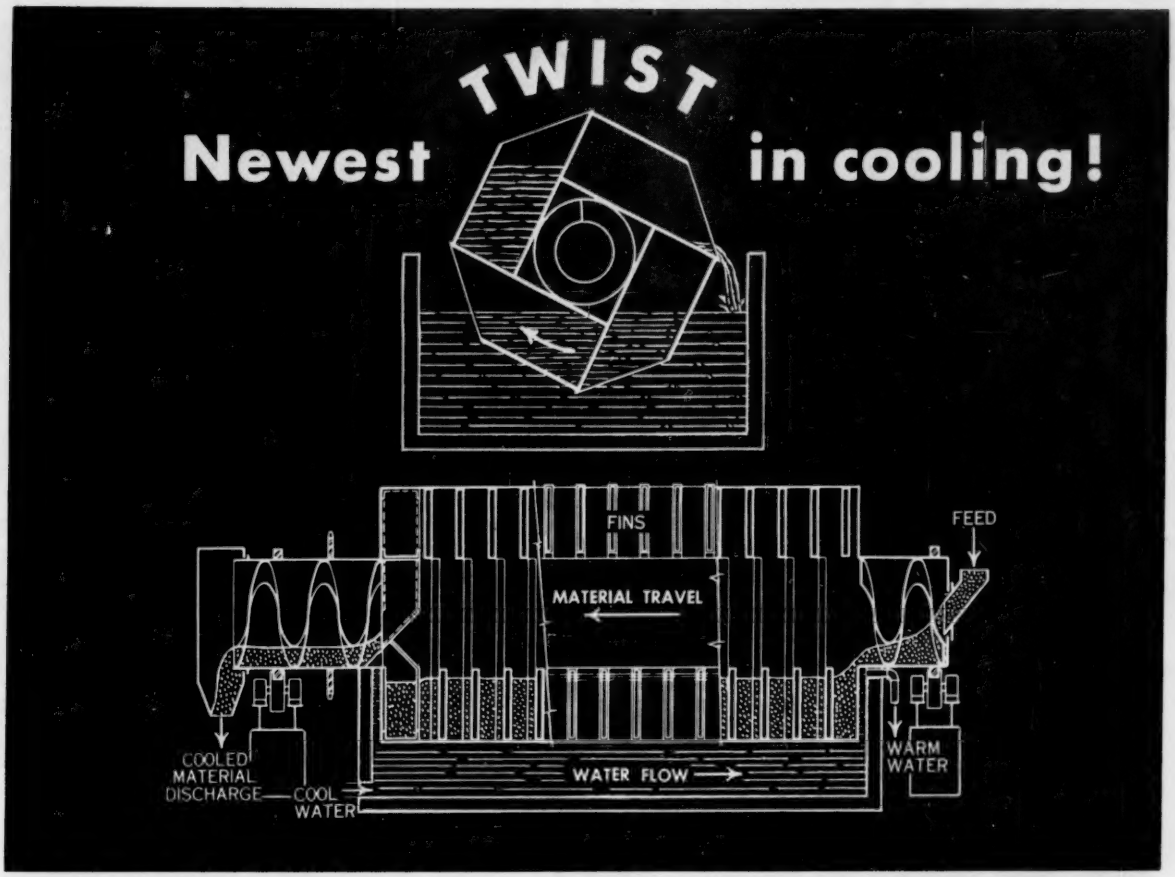


BASIC TO AMERICA'S PROGRESS

Allied Chemical

NITROGEN DIVISION
Dept. AP | 10-5-4, 40 Rector Street
New York 6, New York

2819



HERE'S HOW IT WORKS! The Roto-Fin is a rotating drum with a series of flat, dual-purpose hollow fins or "cells" lapped to form an Archimedes spiral around the inside of the shell. As the cells are welded together, their surfaces form one continuous spiral. Yet individually, each cell is a separate heat exchanger with an opening on the outer periphery of the drum.

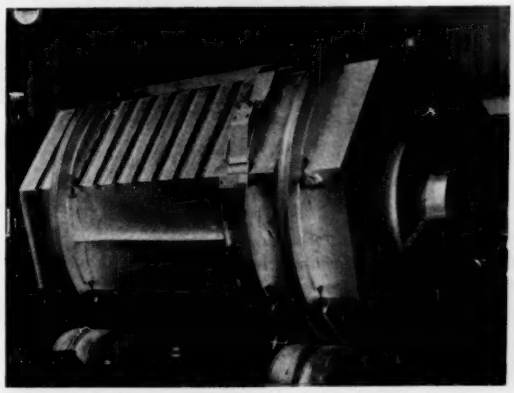
As the drum revolves partly submerged in water, the material to be cooled is conveyed down its spiral length from one turn in the spiral to the next. The openings of the individual cells continuously scoop up cold water and empty with each revolution of the drum to realize overall heat transfer coefficients as high as 20 b.t.u./hr./sq. ft. deg. F. on high temperature applications.

New Link-Belt ROTO-FIN Cooler has deep fin design for maximum cooling surface

Here's an efficient and low cost means of cooling a wide variety of materials. Water-cooled surfaces of rotating fins are in constant contact with product, assuring a rapid transfer of heat.

ROTO-FIN'S design is simple with minimum number of moving parts for continuous, trouble-free operation. No fans, collectors or elaborate controls are required. A unique self-cleaning feature prevents contamination when handling different products.

A laboratory ROTO-FIN is available for testing materials at your plant. Make arrangements by calling your nearest Link-Belt office today.



The Roto-Fin, new conduction-type cooler, rotates in tank of cool water. Deep hollow fins, with water circulating within them and material traveling through the drum between them provide maximum conduction cooling surface.

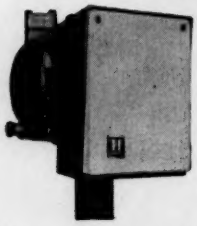
LINK-BELT

COOLERS • DRYERS • ROASTERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses and District Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 18,588

NEW BELLOWS FLOW TRANSMITTER

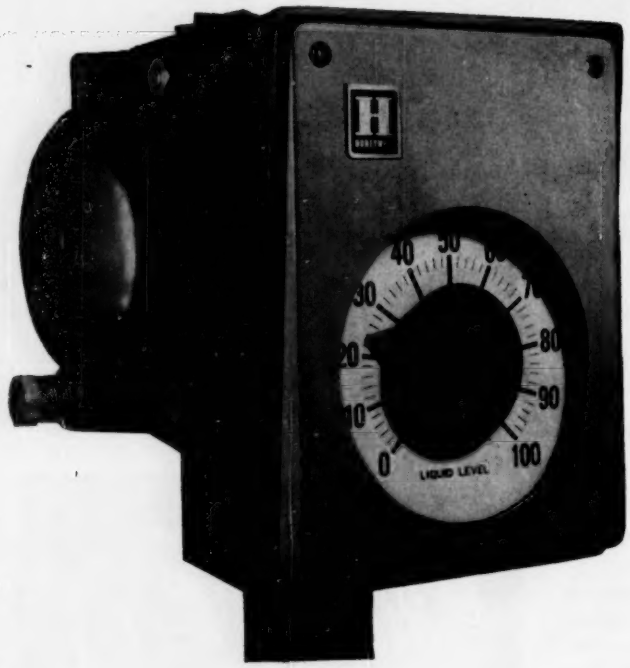
gives you field indication plus convenience and precision



You get all the economy and convenience of pneumatic transmission and all the efficiency of the bellows meter body plus field indication, when needed, in the new Honeywell Bellows Flow Transmitter. Use it in any application to transmit flow or liquid level measurements in open or closed tanks.

This new meter has automatic ambient temperature compensation and two-way overload protection for 100% of span. Maintenance is greatly simplified by modular construction which lets you remove any major component by loosening two screws. All field adjustments are easily accessible, and a self-locking feature prevents upset after calibration adjustments are made.

You can change ranges in the field simply by removing a single spring assembly and replacing it with an assembly of the desired range . . . adjust damping quickly and accurately, while the instrument is in operation . . . install the meter with either vertical or horizontal piping, so that it vents, drains and purges itself. The meter transmits with calibrated accuracy of ±0.5% of full scale, and indicates within ±1.0% of full scale.



New Bellows Transmitter is available with a concentric scale or as a non-indicator. It has 16 ranges—from 0-10 inches of water to 0-400 inches of water.

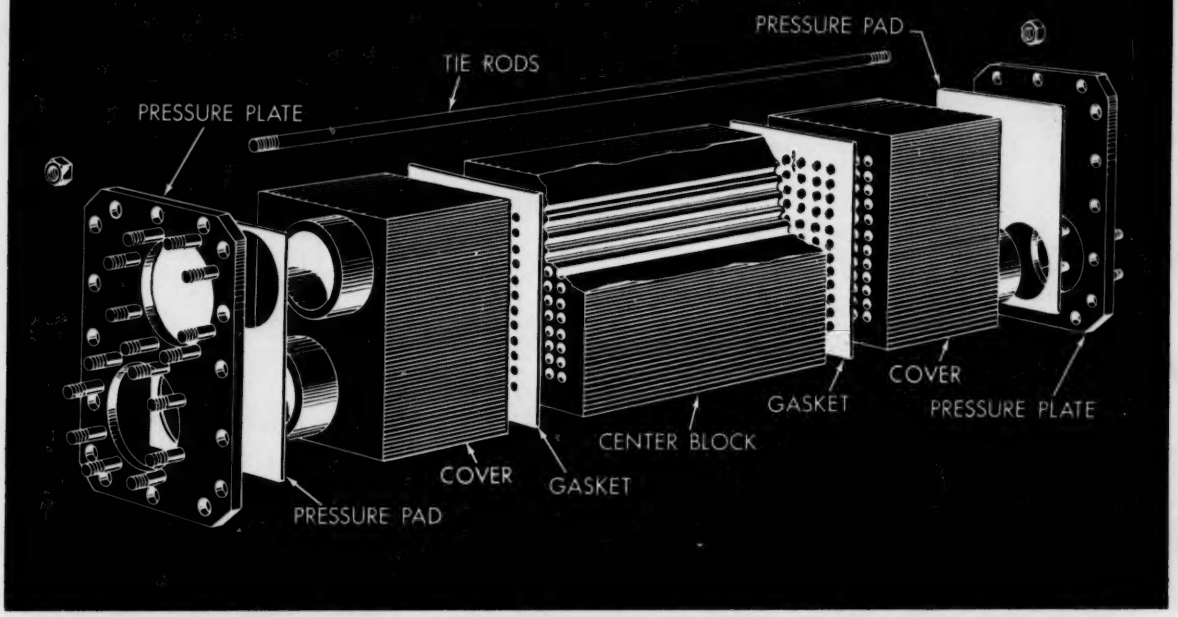
For complete details on the new Bellows Flow Transmitter, call your nearby Honeywell field engineer. Or write MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.—In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

SINCE 1885

Announcing the NEW...



"KARBATE" IMPERVIOUS GRAPHITE COUNTERFLOW BLOCK HEAT EXCHANGER!

You'll get these cost-saving advantages with "Karbate" impervious graphite Type CFB (counterflow block) heat exchangers:

● **Unsurpassed corrosion resistance**—fluids on both sides of this exchanger contact "Karbate" impervious graphite only.

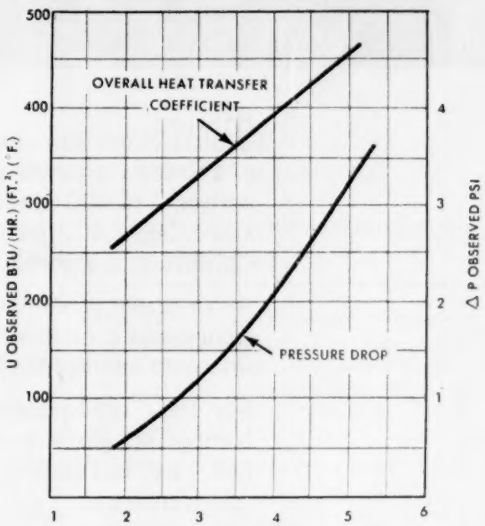
● **High thermal efficiency**—true counterflow design provides most effective use of available temperature differential with minimum pressure drop.

● **Compact design**—only 13 inches x 21 inches in cross-section; when installed vertically the unit provides more heat transfer area per square foot of floor space than any other block type exchanger.

● **Heat transfer area easily changed**—the number of 23-inch-long center blocks can be varied from 1 to 6 to provide a range of areas (for 3-pass unit) from 37.3 to 172.8 square feet.

● **Rugged construction**—sturdy, impervious graphite blocks assemble into single or multi-pass units, operating at pressures up to 100 lbs. per square inch.

For details, write for **Catalog Section S-6813** Address: National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto 12.



TEST DATA FOR TYPE CFB HEAT EXCHANGER
(3-PASS—ONE CENTER BLOCK)

Graph shows typical overall heat transfer coefficient and pressure drop test data for a water-water system in a "Karbate" impervious graphite single center block, 3-pass (both sides), Type CFB heat exchanger.

"National," "Karbate" and "Union Carbide" are registered trade marks for products of

NATIONAL CARBON COMPANY

UNION CARBIDE

This Helium Transport, built by The Taylor-Wharton Division of Harsco Corporation for General Dynamics Corporation can deliver 114,000 standard cubic feet of Helium at a pressure exceeding 2,400 p.s.i. from Amarillo, Texas to Los Angeles, California; a distance of 2,166 miles round trip.

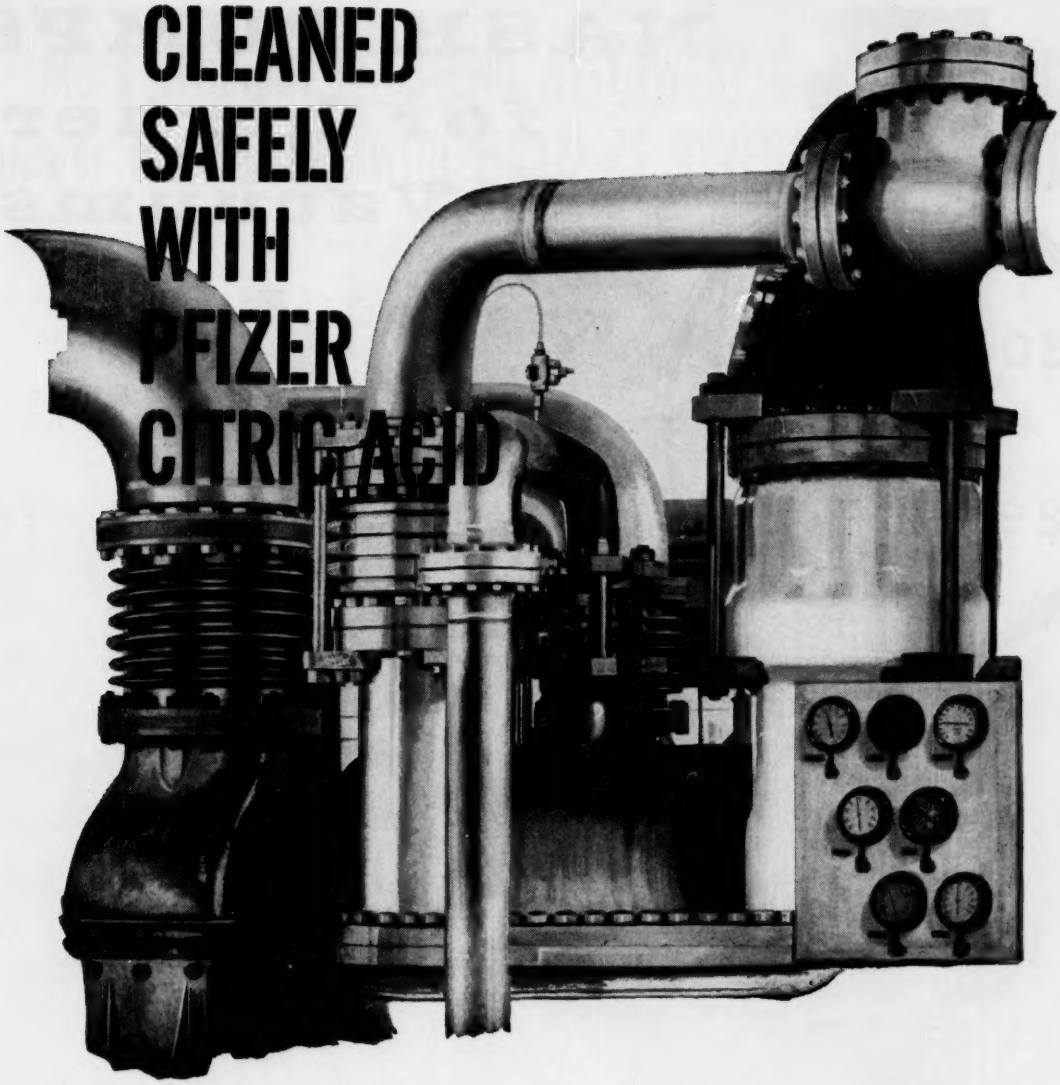
As in many other cases, this transport has provided more efficiency and economy in operations than would have been found in any other means of transportation.

For their semi-permanent storage as well as for transporting compressed gases, many gas producing, oil refining, petro-chemical, food and electronic companies now employ flexible, mobile gas transports.

Why don't you? Write to:

HARRISBURG STEEL CO.
Division of HARSCO CORPORATION
HARRISBURG 26, PENNSYLVANIA

CLEANED SAFELY WITH PFIZER CITRIC ACID



STAINLESS STEEL BOILERS, HEAT EXCHANGERS, ATOMIC INSTALLATIONS, CHEMICAL PROCESSING EQUIPMENT CLEANED SAFELY, EFFICIENTLY WITH PFIZER CITRIC ACID

● Industry experience proves that citric acid eliminates chloride stress corrosion problems — provides effective descaling — permits easier, more efficient after-rinsing.

Discuss with your chemical cleaning service company these advantages of Pfizer Citric Acid in stainless steel cleaning solutions:

1 Citric acid is highly efficient in removing imbedded metal and oxide films from stainless steel.

2 Citric acid's excellent sequestering ability prevents reprecipitation of dissolved scale.

3 Citric acid cleaning eliminates the problem of chloride stress corrosion.

4 Citric acid can be effectively inhibited without losing its cleaning or sequestering ability.

5 Citric acid is sold as a dry, 100% acid — meaning savings in storage and handling.

6 Citric acid is water soluble, easy to handle, and non-toxic.

Let us send you further information, cost and obligation-free!

I want to learn more about the use of Pfizer Citric Acid for cleaning stainless steel equipment. Please send me Technical Bulletin 102.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

Science for the world's well-being

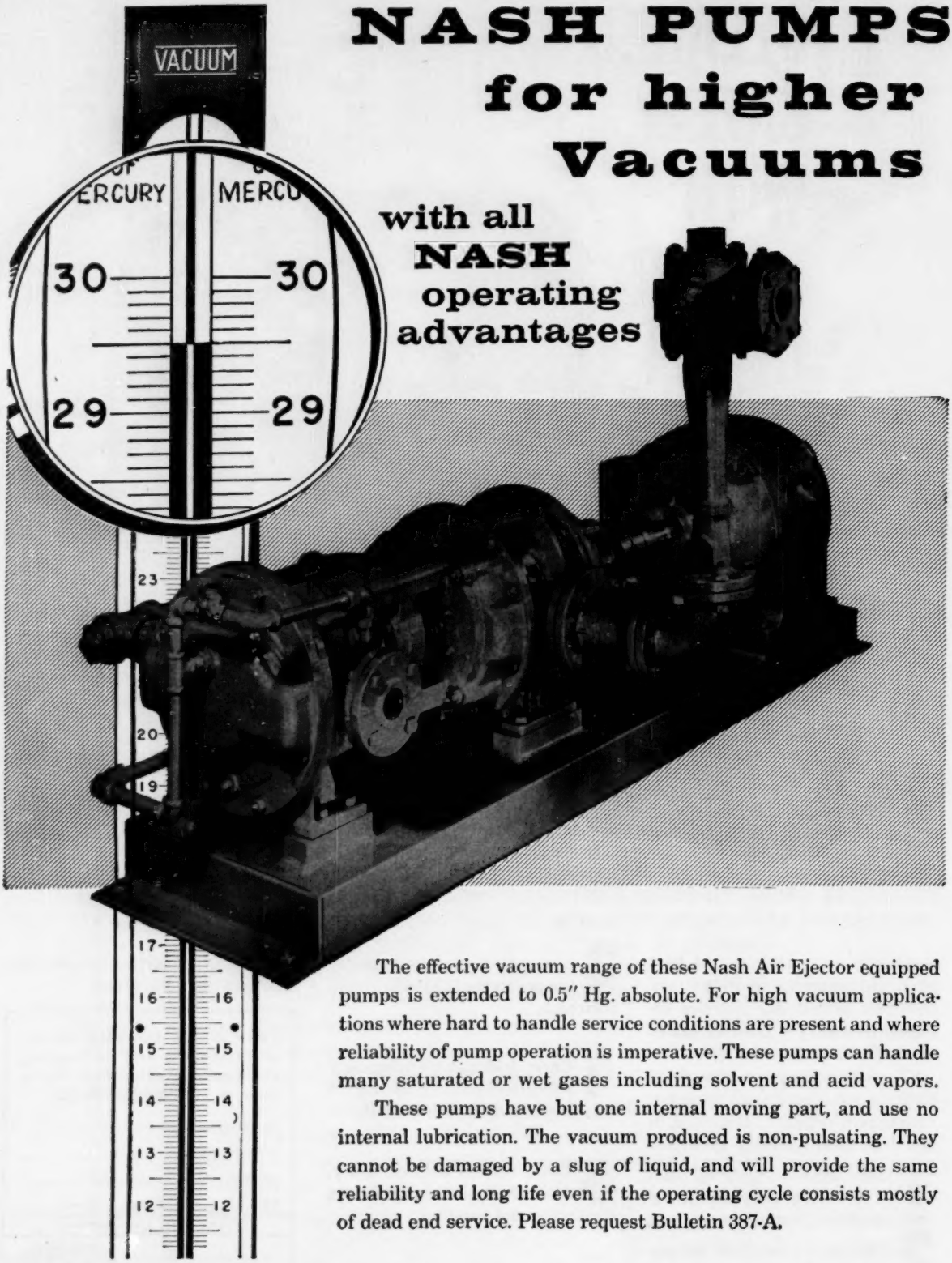
Manufacturing Chemists for Over a Century

Pfizer

CHAS. PFIZER & CO., INC., CHEMICAL SALES DIV., 630 FLUSHING AVE., BROOKLYN 6, N. Y.
Branch Offices: Clifton, N. J.; Chicago, Ill.; San Francisco, Calif.; Vernon, Calif.; Atlanta, Ga.; Dallas, Tex., Montreal, Canada

NASH PUMPS for higher Vacuums

with all NASH operating advantages



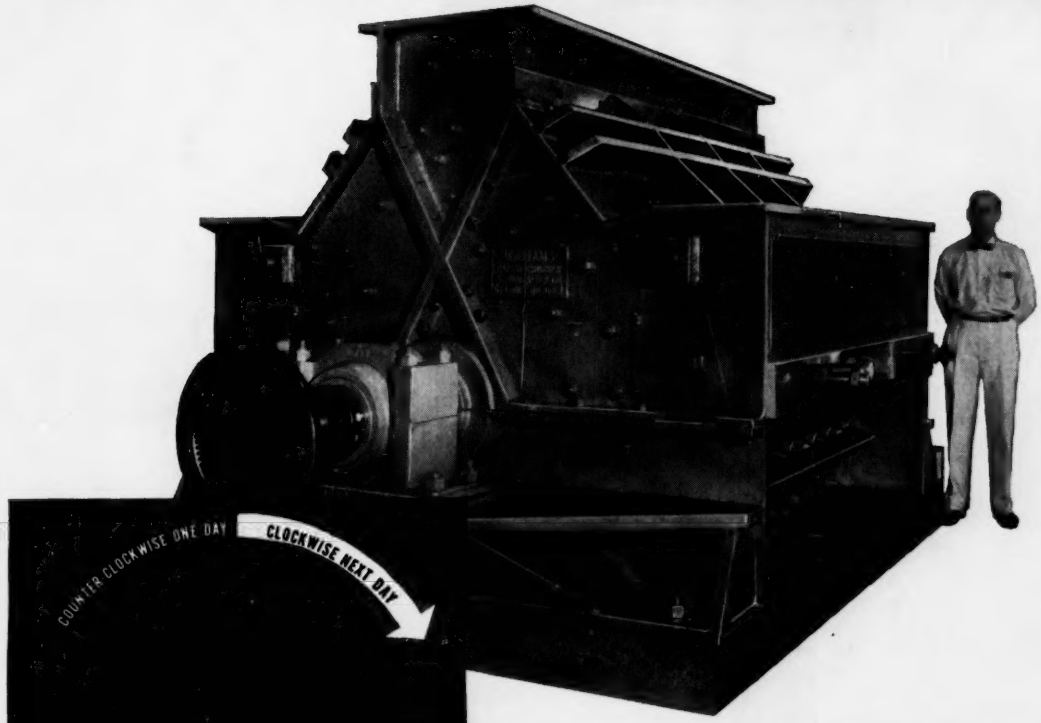
The effective vacuum range of these Nash Air Ejector equipped pumps is extended to 0.5" Hg. absolute. For high vacuum applications where hard to handle service conditions are present and where reliability of pump operation is imperative. These pumps can handle many saturated or wet gases including solvent and acid vapors.

These pumps have but one internal moving part, and use no internal lubrication. The vacuum produced is non-pulsating. They cannot be damaged by a slug of liquid, and will provide the same reliability and long life even if the operating cycle consists mostly of dead end service. Please request Bulletin 387-A.

NASH ENGINEERING COMPANY

SOUTH NORWALK, CONNECTICUT, U. S. A.

More efficient CRUSHING AT LOWEST COST for labor, power and upkeep with WILLIAMS REVERSIBLE IMPACTOR



REVERSIBLE ROTATION prolongs parts life without manual adjustment. A simple reversing switch on motor does it.

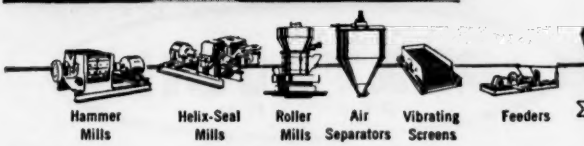
INTERIOR VIEW of small Impactor shows typical rugged hammers, impact blocks and liners made of manganese steel and other alloys. Rotor removable without disturbing feed or other mechanisms.

For secondary crushing, the economy and high production of a Williams Reversible Impactor is unequalled, whether raw material is hard and abrasive or soft and friable. Precision control of specified top-size is easy, usually in a closed circuit system, from a coarse 2" with minimum fines, down to 35 mesh or finer.

The Impactor has no grates. Material fed into the mill is reduced to proper size while rebounding between the whirling hammers and impact blocks, until discharged from bottom opening. Grinding or rubbing action is eliminated—power, replacement parts and downtime are reduced to a minimum. No fine adjustments need be maintained.

Reversible rotation is a prime feature of the Williams. So is *Wide Open Accessibility* to interior. So are the *Interchangeable Impact Blocks* to balance wear. So are the many other exclusives that hold cost-per-ton to the very lowest. There is a size and model for your exact needs. *Write for catalog.*

WILLIAMS PATENT CRUSHER AND PULVERIZER CO.
2706 N. 9th Street • St. Louis 6, Mo.



Hammer Mills · Helix-Seal Mills · Roller Mills · Air Separators · Vibrating Screens · Feeders

WILLIAMS
CRUSHERS · GRINDERS · SHREDDERS
Oldest and largest manufacturers of hammer mills in the world

PLATECOIL®

SOLVES TANK AND PROCESS HEATING AND COOLING PROBLEMS

These are but a few examples of hundreds of PLATECOIL which have been especially formed and fabricated to meet a processing or manufacturing requirement. Today, in addition to standard styles (which in themselves offer a broad range of application possibilities) PLATECOIL can be rolled, formed and shaped to satisfy rigid requirements of space, configuration, weight and materials.

PLATECOIL saves on engineering, fabricating, installing, and maintenance in comparison with pipe-coils. Greater heat transfer capacity permits compact units which save space.

Operating pressure up to 250 psig. Safety factor 5 to 1. Available in stainless steel, mild steel, Monel, Nickel, Inconel, Ni-O-nel, and Hastelloy B, C, and F or other weldable materials on special order.

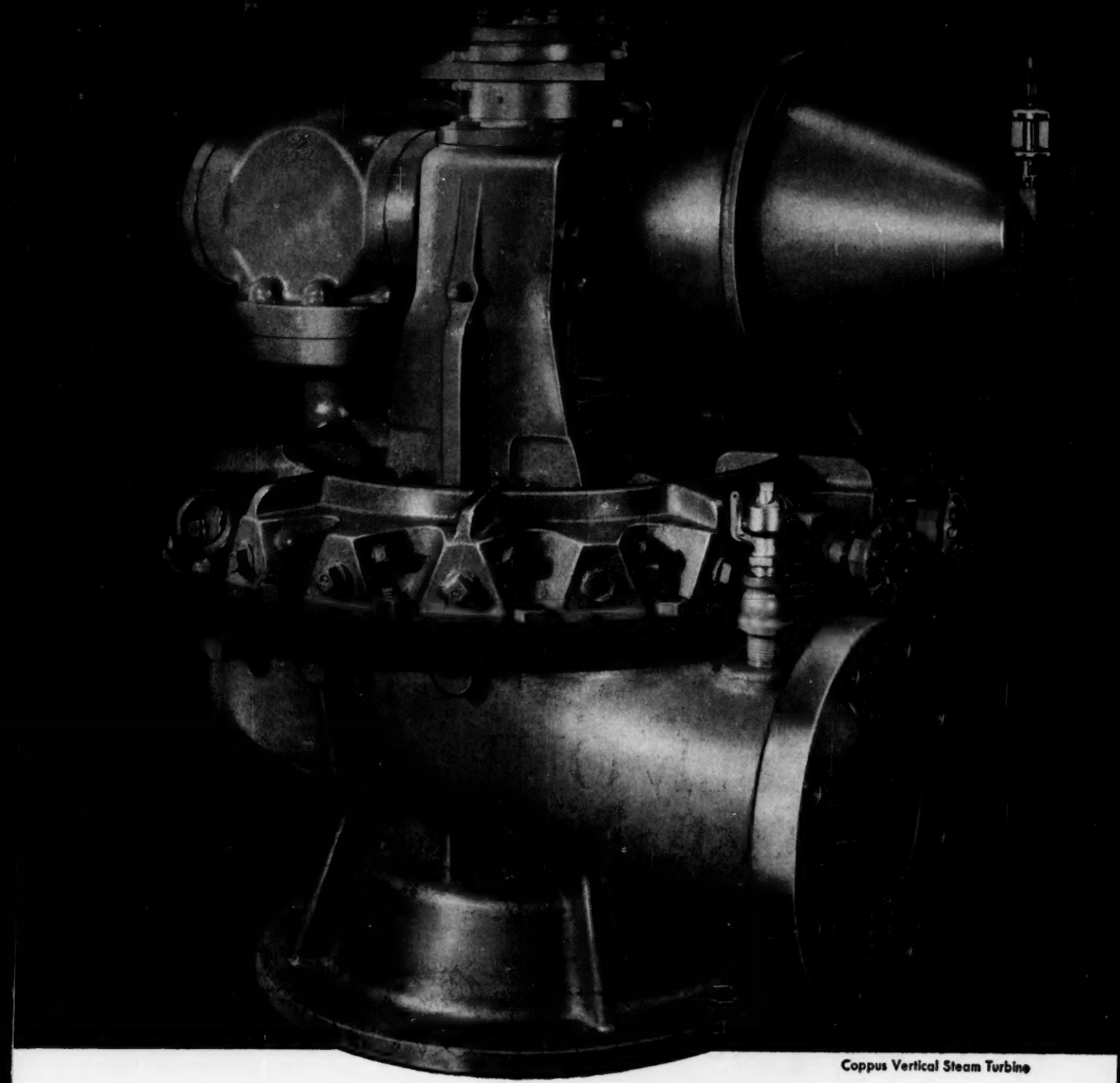
BUILT TO SPECIFICATIONS

Send for PLATECOIL® Bulletin P-61.

Tranter Manufacturing, Inc.
LANSING 9, MICHIGAN

PLATECOIL® DIVISION

COPPUS BLUE RIBBON PRODUCTS



Coppus Vertical Steam Turbine

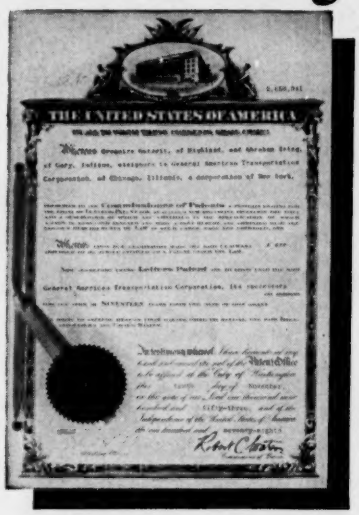
THE MARK OF QUALITY — There's no better test of a turbine's quality than performance. And the new, ruggedly designed, power-packed Coppus Turbines pass all performance tests with top honors! Small wonder. Coppus quality is literally designed and built into them. Their super stamina is the end-product of painstaking craftsmanship, finest materials and methods, thorough testing and control. Each truly deserves its Blue Ribbon . . . assurance of *complete* reliability.

Typical Coppus Blue Ribbon features are: ***totally enclosed governor . . . totally enclosed and independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.*** You get higher efficiency operation . . . less down time . . . lower maintenance costs.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Send for Catalog 200. Get complete details on Coppus Turbines. Sizes from 1 HP to 250 HP. Write COPPUS ENGINEERING CORPORATION, 223 Park Avenue, Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES

a Reminder *to those who use chemical nickel alloy plating:*



There is only ONE Kanigen®

and 29 patents prove it

There are no substitutes for Kanigen—no other process that applies a hard, corrosion-resistant nickel alloy coating without the use of electricity as Kanigen does.

With Kanigen, you can plate anything from a small relief valve to a 20,000 gallon tank car with a virtually non-porous, uniform coating.

How can you be sure of getting Kanigen? Only one way—by calling General American or one of its licensees. For further information write:

Kanigen Division
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South LaSalle Street
Chicago 3, Illinois
Offices in principal cities

LICENSEES

INDUSTRIAL KANIGEN CORPORATION
1421 Park Avenue
Emeryville, California

KEYSTONE CHROMIUM CORPORATION
1095 Niagara Street
Buffalo, New York

KEYSTONE METAL FINISHERS, INC.
22 Raydol Avenue
Secaucus, New Jersey

DESIGNED FOR MODERN PIPING!

ILLUSTRATED:
1" SIZE
SIZE RANGE:
¼" TO 6"

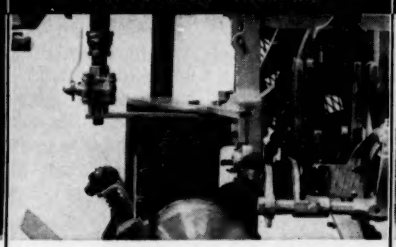
THE ECON-O-MISER BALL VALVE

COMPACT PIPING LAYOUT

Here are 19 Econ-O-Miser Ball Valves compactly installed on this paint blending manifold. Note the absence of unions . . . this valve is both a valve and a union! The Econ-O-Miser is smaller, easier to install . . . just right for modern piping layouts, where equipment must fit into tight areas.

Let us show you . . . in your own plant! Write us about your limited space problems!

DIFFICULT MEDIA



The Econ-O-Miser Ball Valve successfully controls the flow of cold glue with a viscosity of molasses, on the WORLD Tandem Labeler manufactured by Economic Machinery Co. Clean wiping action, positive leakproof shut-off, and smooth round flow, make the Econ-O-Miser ideal for handling difficult media.

Let us show you . . . in your own plant! Write us about your media problems!

TROUBLE-FREE OPERATION

Outdoor propane and butane storage tanks in remote field processing plants require dependable positive shut-off valves on bleed lines. The unique features of the Econ-O-Miser Ball Valve provided the practical answer . . . no lubrication . . . no metal-to-metal contact . . . quick visual ON-OFF indication . . . trouble-free service.

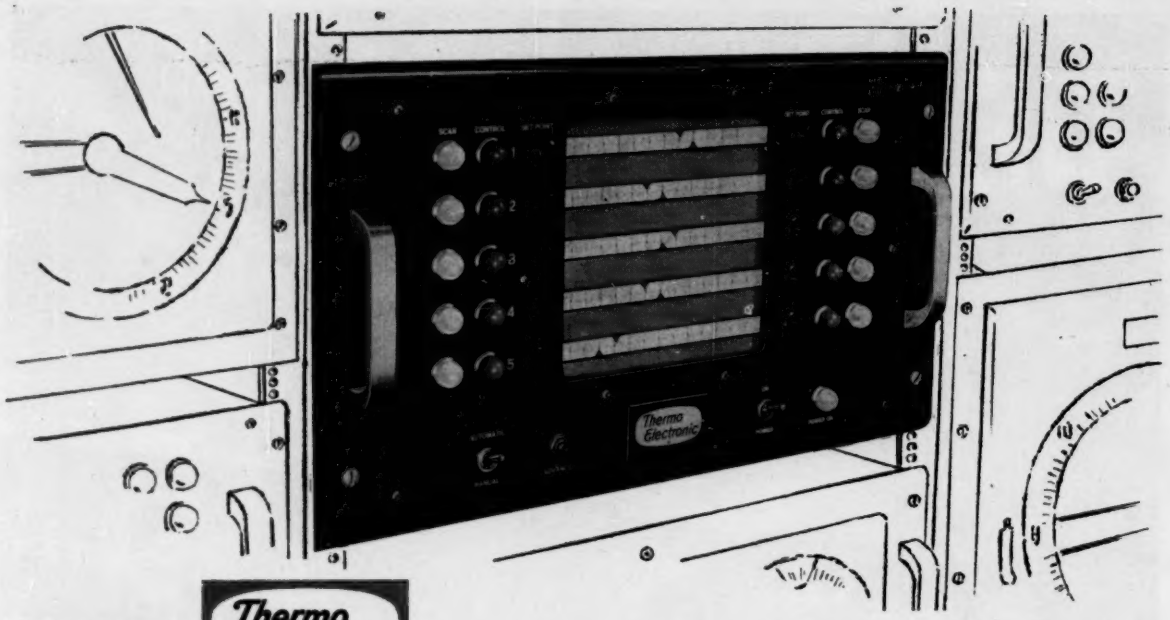
Let us show you . . . on your outdoor applications! Write us about your valve maintenance problems!

COMPARE . . . THE ECON-O-MISER BALL VALVE

NO UNION NECESSARY

WORCESTER VALVE CO., INC.

16 PARKER STREET, WORCESTER, MASS.



ONE Thermo Electronic Multi-Point Controller

Controls TEN Process Temperatures

One, compact "Thermo Electronic" Multi-Point Controller gives you, sensitive, accurate, automatic . . .

- Two position (off-on) control of up to ten separate process temperatures; also controls flow, pressure, pH, Strain gages, and other operations.
- Three position control of five separate processes!
- Single point constant control of any critical process!
- Manual-Balance Indication of exact process conditions!
- Monitoring of extra points or those already under control!

Ten in One

One instrument does the job of ten individual controllers. You save—40 to 60% of initial cost—up to 75% of panel space —cut installation time and cost—minimize maintenance!

Clean, Simple, Functional Design

The "Thermo Electronic" Multi-Point Controller has front-set controls for easy operation. Routine maintenance is also done from the front, without removing unit from panel or relay rack. Available in either potentiometer or bridge measuring circuits, with an extremely stable constant voltage supply, the instrument provides long-lived, trouble-free control of practically every process suitable to off-on control action. Sensitivity is 15 microvolts independent of scale span—Accuracy is ±0.5% of scale span.

Operation

Sensing element input signals are compared, in sequence, to individually adjustable slide-wire set-points. Signal deviations are amplified by the "Thermo Electronic" high-gain relay control amplifier, and used to actuate load relays connected to the points being controlled.

Scanning sequence is governed by a stepping switch and electronic timer. Scanning rate—3 seconds per point. Other scanning speeds are available by simply changing one carbon resistor.

Ten white lights on the instrument panel show scanning position—ten red lights show process condition. Ten knobs permit adjustment of individual set-points on the range scales. Ranges are available for thermocouples, resistance temperature detectors and other types of suitable transducers.

Maintenance Is Easy

The instrument slides forward on built-in tracks. Simple adjustment and inspection is easily accomplished from the front. The plug-in or screw-terminal components are easily replaced—fully protected from dirt and corrosive atmosphere. The whole instrument is gasketed to further protect components.

Safety Engineering

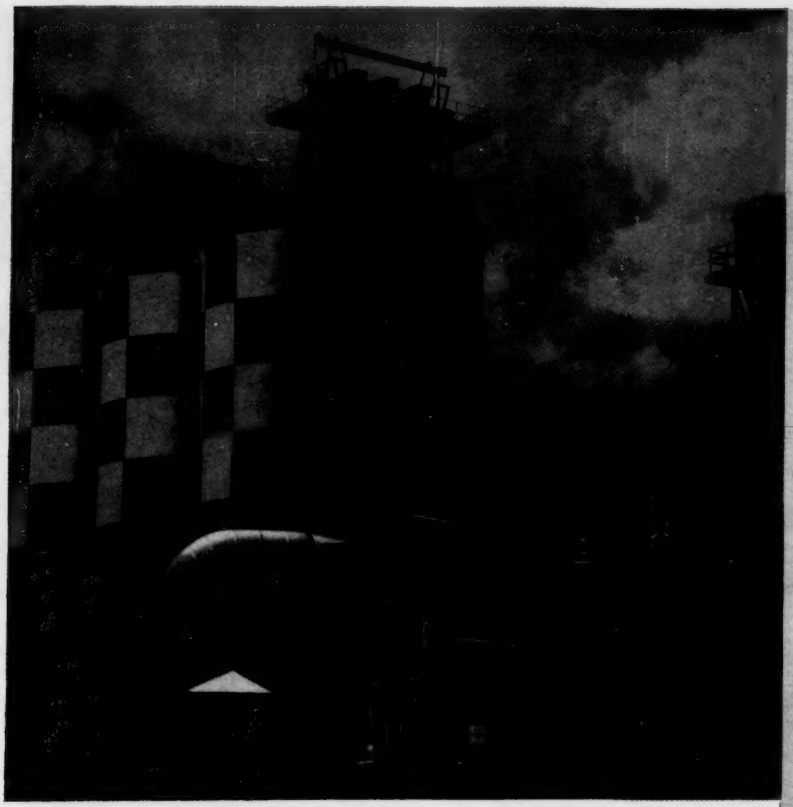
Critical circuitry is fused against overloading. A failsafe circuit is provided to protect processes against thermocouple burn-out and amplifier component failure.

Write today for Instrument Section 52-4

Thermo Electric

Temperature Measuring Systems and Components

THERMO ELECTRIC Co., Inc., Saddle Brook, New Jersey
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.



Performing a TOP JOB... The MIKRO-PULSAIRE DUST COLLECTOR

Installed at the Hawaiian Cement Company's new plant at Barber's Point, Oahu, you'll find a total of nineteen MIKRO-PULSAIRE Dust Collectors, four of which are pictured above.

Because it has no moving parts . . . internally or in the gas stream . . . the MIKRO-PULSAIRE has proved ideally suited to handling highly abrasive materials such as cement. Other features to be considered are its record of 99.9% *plus* recovery, and high air-to-cloth filter ratio. Our Hawaiian installation provides a total filtering capacity of 329,928 cfm. Whatever your requirements, the MIKRO-PULSAIRE can deliver a top job for you, economically and with maximum dependability.

A tradition... and a trademark...

Like the craftsman whose work carries the Sterling symbol, Mikro designers, engineers, technical service staff and production men assign a high standard of excellence to every item of MIKRO-trademarked equipment. This quest for quality, plus MIKRO-Products' long experience in the field, assure every user the utmost in performance and reliability.

PROCESSING SYSTEMS

MIKRO-Products....

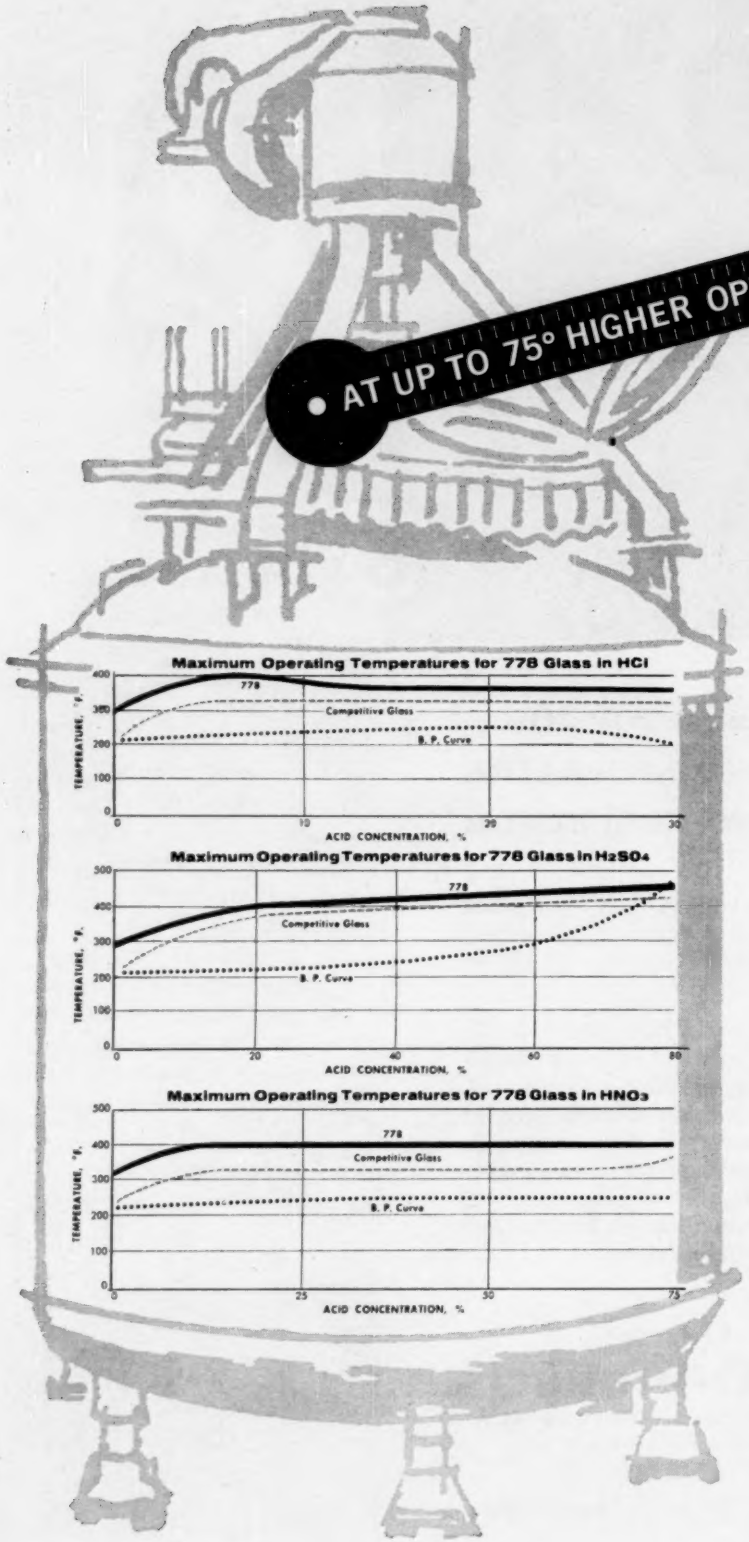
PULVERIZING MACHINERY COMPANY
55 Chatham Rd., Summit, N. J.
A Division of American-Marietta Company

REPRESENTED THROUGHOUT THE WORLD IN SALES, SERVICE AND MANUFACTURING FACILITIES.

MORE ACID RESISTANT

AT UP TO 75° HIGHER OPERATING TEMPERATURES

and now standard on all GLASCOTE process equipment



Take a good look into the Glascote reactor shown at the left — it contains proof that you can speed reaction time in vessels lined with sensational Glascote 778 . . . that you get a glass lining that extends acid resistance to 75° F higher operating temperature. And all this with no sacrifice in its ability to resist alkalies and thermal shock.

No wonder so many of our customers specified Glascote 778 . . . small wonder that we have this remarkable acid-resistant glass standard on all Glascote reactors, columns, storage tanks, rotary dryer-blenders, pipe and fittings. But keep in mind that this popular glass lining is just one of over 3000 formulations. Some may be even more effective for special requirements.

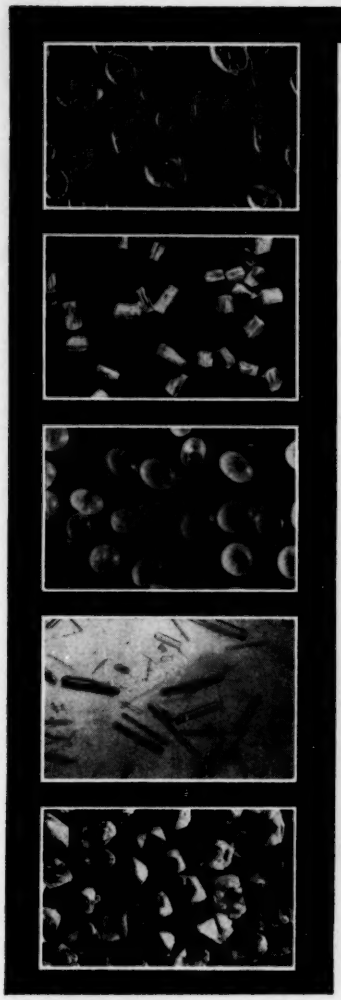
For your convenience we have prepared a special "resistance rule." It lists 150 chemicals and shows at a glance the ability of Glascote 778 to resist their corrosive attacks. Send for your rule today or see your Glascote representative.

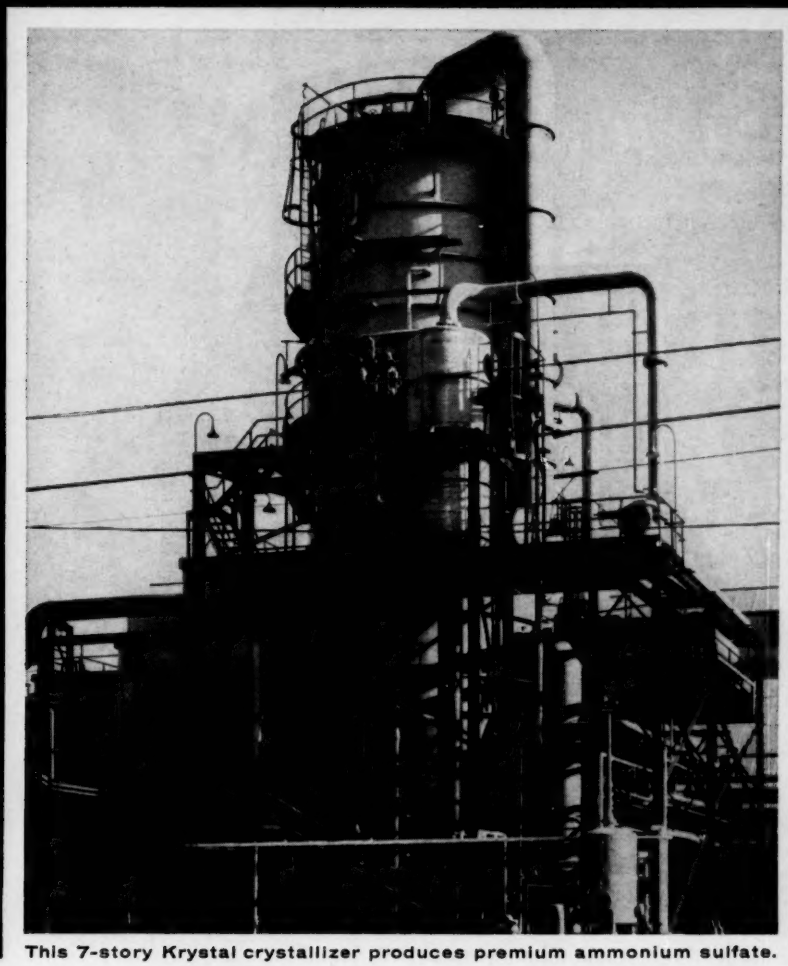
Through research . . . a better way

A.O.Smith
CORPORATION

Subsidiary: GLASCOTE PRODUCTS, INC.
Cleveland 17, Ohio

World's largest manufacturer of glass-protected steel products





This 7-story Krystal crystallizer produces premium ammonium sulfate.

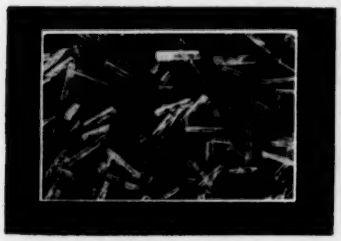
How to reduce overall costs when purchasing CRYSTALLIZATION EQUIPMENT

Achieving maximum crystallization economy involves far more than initial cost. The key point is efficiency, and this is vastly more important than purchase price in the analyses of overall costs.

It includes money-saving steam features, high product purity, controllable and uniform crystal size, efficient separation of crystals and mother liquor, reduction of wash water, economical dryer operation, dust reduction and reduction of material caking.

Our crystallization know-how at Struthers Wells enables us to provide all of these features—and more. We do this by supplying you—not just a standard crystallizer—but a crystallizer *tailor-made to suit your requirements.*

Over the years, Struthers Wells has designed, fabricated and erected hundreds of commercial installations in this manner. Write us about your requirements. Ask for our 16-page engineering bulletin.



Struthers Wells

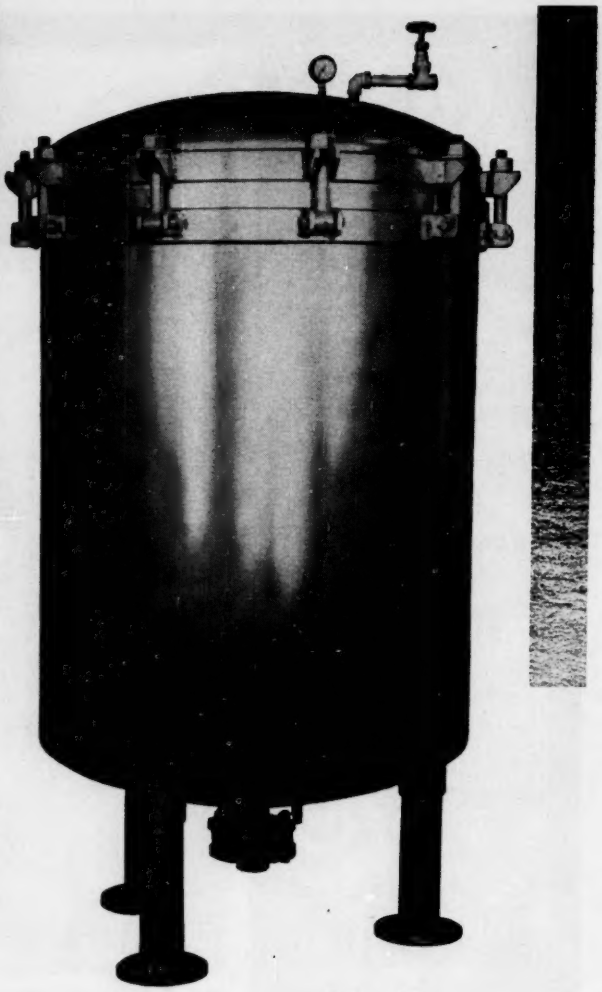
STRUTHERS WELLS CORPORATION

WARREN, PA. plants in Titusville and Warren, Pa.

Designed for TRAP FILTRATION

SPARKLER MODEL VR 17-33 FILTER OFFERS

- 100 Sq. Ft. Filtering Area
- Exclusive Scavenger Plate Feature
- Less than $4.00 for New Plate Dressing
- Only $1490.00*

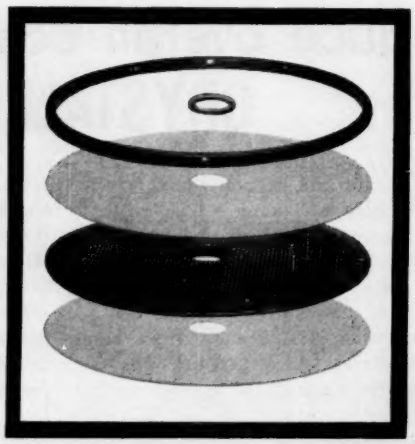


The Model VR Filter is adaptable in many applications for removal of any traces of solids following regular filtering operation.

Low Operating Cost results from (1) use of disposable paper filter media costing less than $4.00 for complete new plate dressing (Model VR 17-33), and (2) quick cleaning.

Trap filtration can now be included in your processing at an unusually low cost when you use the Sparkler Model VR Filter. Other sizes available from 5 to 350 sq. ft. of filtration area. Technical bulletins available on request. Representatives in all major cities.

*Complete in carbon steel, less piping; priced for Continental U. S. A. only.



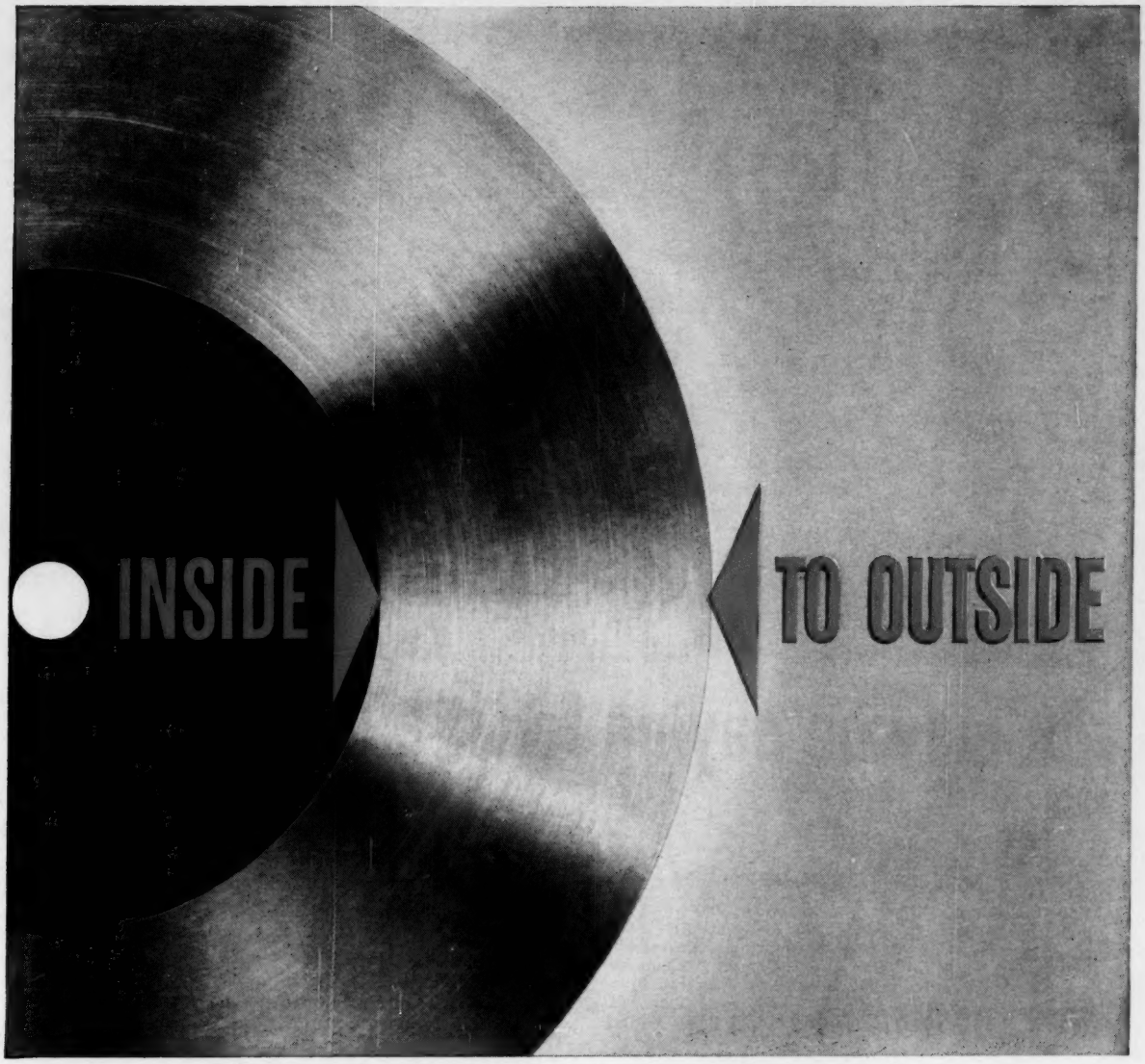
V-shaped screen plate with outlet holes in center is covered top and bottom with filter paper, sealed with outer ring. Each plate separated by small spacer ring at center.

SPARKLER FILTERS

SPARKLER MANUFACTURING CO.
Conroe, Texas

Sparkler International Ltd. manufacturing plants in: Canada; Holland; Australia; Italy; Brazil; Mexico.

FILTRATION ENGINEERS EXCLUSIVELY FOR OVER 36 YEARS 253

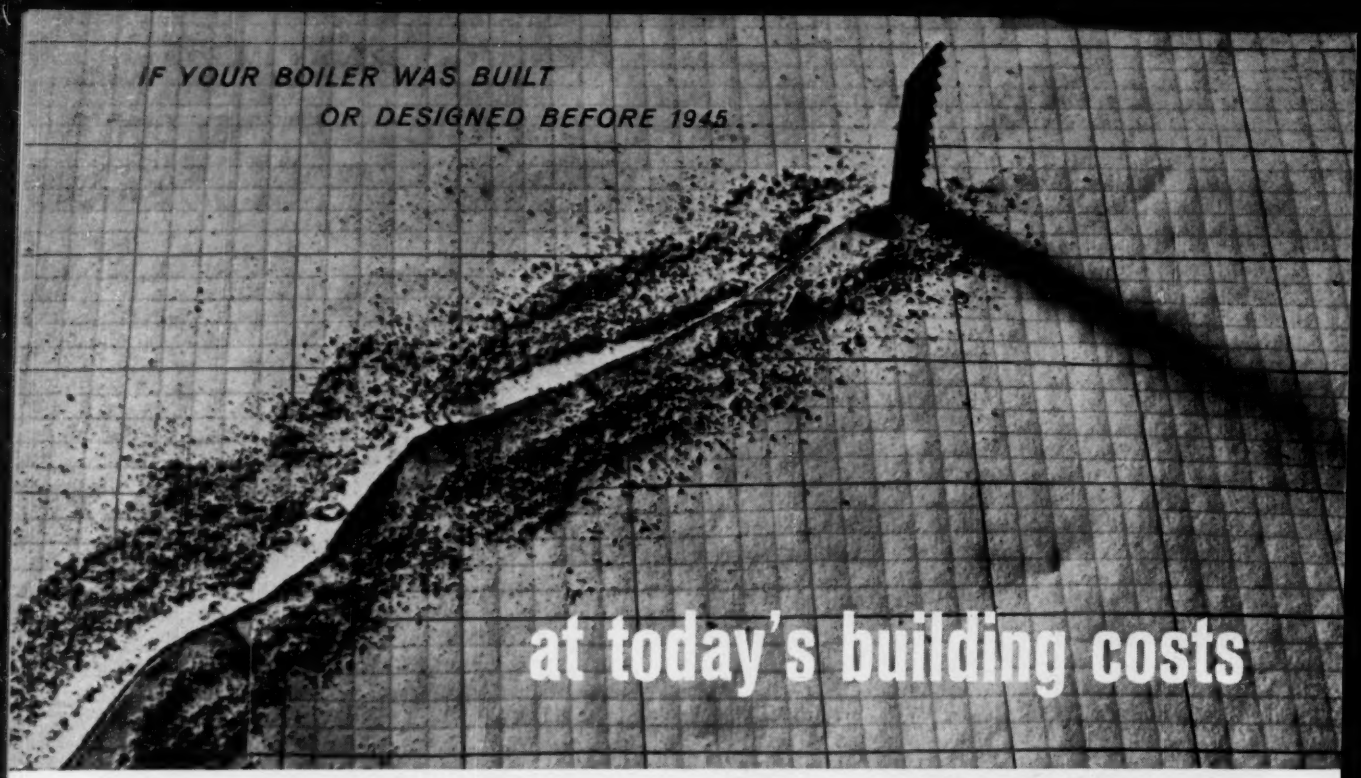


maximum tube life per dollar—When you buy Timken® seamless steel pressure tubing, you receive fine forged quality that is uniform from heat to heat, tube to tube, order to order. We target it to your end use. And our metallurgists draw from a background of over 40 years' experience to help you select the one tube that will give you maximum tube life per dollar.

Timken seamless steel tubing is available in carbon, alloy and stainless grades, up to 11" O.D. and 3¼" wall. And there's a Timken seamless steel pressure tube to meet practically any combination of temperature, pressure or corrosion. For help that assures your selection of the one tube that will be most economical and perform best for you, call in Timken Company metallurgists. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN®
FINE ALLOY STEEL

TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES



you may be paying for it a second time!

Today, with building costs twice what they were in 1945, your big, old boiler — possibly coal-fired — can cost you money by occupying space that might be used for other needs.

To offset these climbing construction costs and meet the compact requirements of modern architecture, one manufacturer, Cleaver-Brooks, has proved that big boiler performance and capacity can be engineered into a compact boiler package. Today's CB packaged boilers — in addition to solving unusual installation problems, such as low headroom — are releasing sizeable ground-level areas for production or storage purposes. In some cases, "penthouse" installations have utilized space on an upper floor and *completely eliminated* the use of ground-level space.

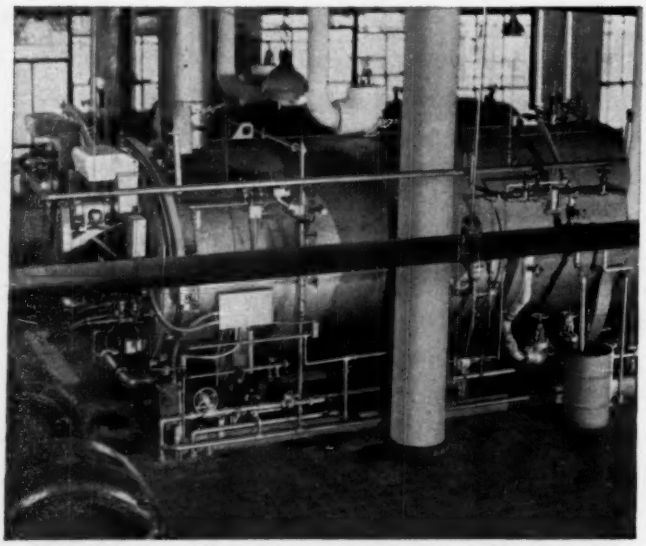
Here are some of the design features that combine for maximum space-saving: four-pass design, forced-draft combustion, updraft construction and all the advantages of five square feet of heat-transfer surface per boiler horsepower. These standards of quality and compactness are only available from Cleaver-Brooks, manufacturers of the most compact, fuel-saving packaged unit on the market.

Cleaver-Brooks boilers are completely pre-engineered and tested as a package . . . expertly started for you by a trained field engineer. Sizes through 600 hp . . . oil, gas and combination oil-gas firing . . . larger sizes in Cleaver-Brooks Springfield water-tube boilers.

Ask your local Cleaver-Brooks agent for more details or write for the booklet, *How to Select a Boiler.*

BOILER ROOM CONVERTED TO WORK AREA

Robert A. Johnston Company, cookie, candy and chocolate products manufacturer in Milwaukee, Wisconsin, replaced four coal-fired boilers with two fully automatic, gas-fired CB boilers. Mr. James Vida, plant engineer, reports: "Compact Cleaver-Brooks design made it possible for us to install the boilers in another part of the plant — in an area of only 750 sq. ft. — releasing the old boiler room, 9000 sq. ft., for storage and work areas. It saved us the cost of an expansion project."

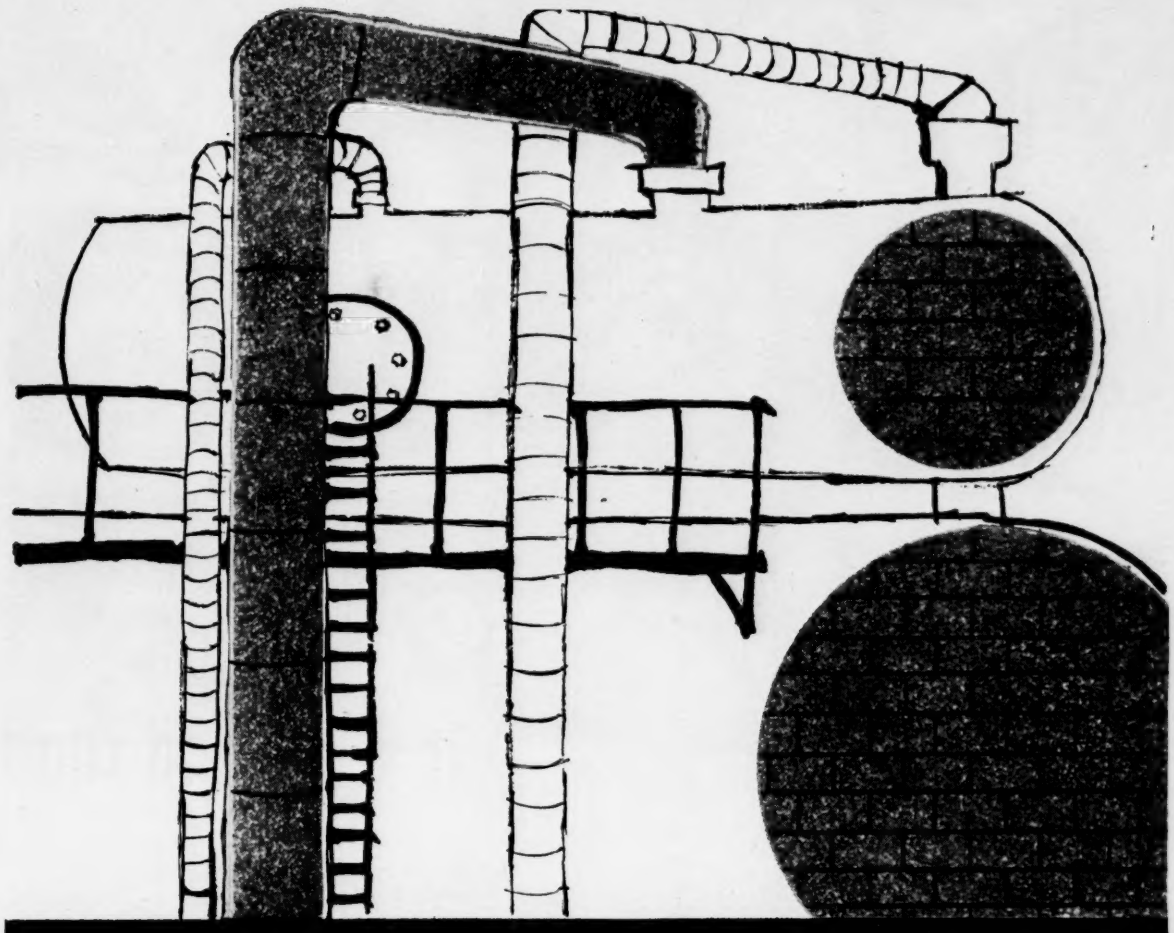


Cleaver Brooks®

ORIGINATOR AND LARGEST PRODUCER OF PACKAGED BOILERS

CLEAVER-BROOKS COMPANY

Dept. C, 345 E. Keefe Ave., Milwaukee 12, Wisconsin



FOAMGLAS® Insulation works for CALIFORNIA OIL COMPANY

EVIDENCE: In 1951, California Oil Company selected FOAMGLAS Insulation for their alkylation plant at their Perth Amboy, New Jersey, refinery. Ten years later FOAMGLAS is still delivering consistent service, temperature control and fire protection on reactors, drum exchangers, and piping in the complex high octane blending operation.

Long-lasting, trouble-free insulation is a result of the completely waterproof nature of FOAMGLAS. The inorganic insulation ignores moisture, keeps a constant K-value and lasts for the life of the equipment. The closed glass cell composition holds temperatures at the required 30°F to 60°F in outdoor alkylation units and piping.

Another important benefit for California Oil is the incombustibility of FOAMGLAS, reducing fire hazards. And FOAMGLAS protects against smoke, dirt and acids in the refining operation.

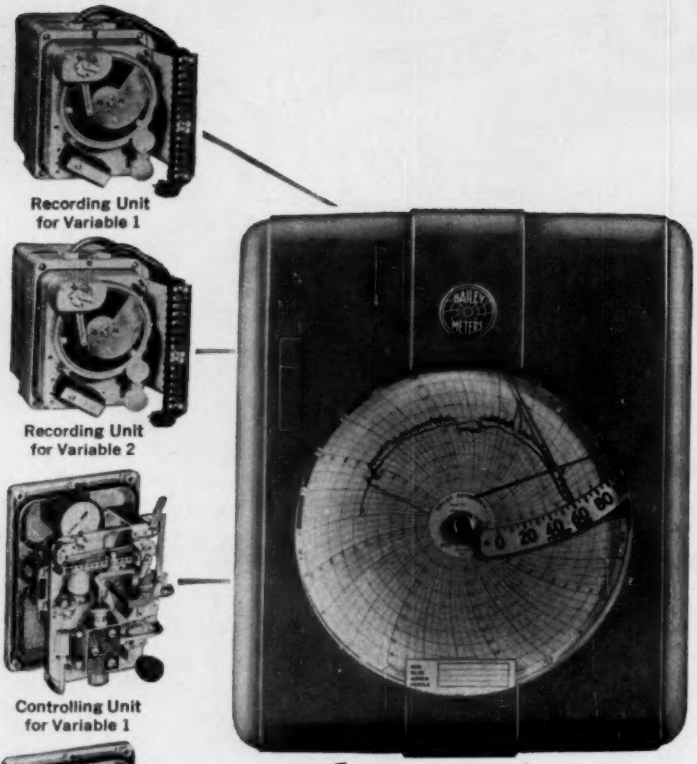
Let FOAMGLAS solve your most demanding insulation problem above or below ground, indoors or out, on piping, tanks, equipment, valves or fittings. For more details, write to Pittsburgh Corning Corporation, Dept. H-31, One Gateway Center, Pittsburgh 22, Pa. In Canada: 3333 Cavendish Blvd., Montreal, Quebec.

Pittsburgh Corning makes available a complete line of accessory materials for use with FOAMGLAS. Write for Data Sheets.

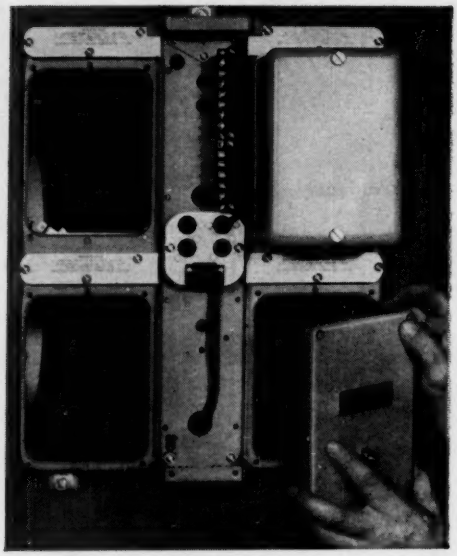
PITTSBURGH

PC

CORNING



Back of Bailey Recorder, showing how four plug-in units may be added as needed.



Key to "step-by-step" automation . . .

BAILEY RECORDERS

with plug-in flexibility

When you are pioneering a new process and don't know all the answers, complete automation is seldom practical. The first step is to identify your variables and measure them. Nothing does this job better than a Bailey Recorder. One instrument can record any four variables that can be converted to electric *or* pneumatic signals.

Then you will want to add controls and feed back your measurements. Here's where the versatility of the Bailey Recorder comes into play. For the same Bailey instrument you use to record variables is designed to accommodate plug-in control units.

When you use a Bailey Recorder, you can build your instrumentation along with your process. At the start, you use only the plug-in units for recording. Then you add plug-in controls as you see the need for them.

For the complete story of how you can use a Bailey Recorder for step-by-step automation, contact your local Bailey Engineer.

CP111-1

Chemical and petroleum division

BAILEY METER COMPANY

1054 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

Cylindrical plug prevents wedging in W-K-M's ACF® Lubricated Plug Valve

With *no* taper, the W-K-M plug can't wedge, can't unseat. *This cylindrical plug can only rotate* — like a journal in a well-lubricated bearing. Result? Even with abrasive ladings the valve remains continuously lubricated and free-turning . . . sealed by a film of grease around the plug and a ring of Teflon at the head.

Wherever service is demanding, or interruptions are costly, specify the valves that *can't wedge* — ACF Lubricated Plug Valves.

WRITE FOR CATALOG 400

Available in either full port or reduced port; rectangular, round, diamond and V-ports; also venturi, multiport and steam-jacketed models.
Materials: semi-steel, Ni-resist, bronze, aluminum
Sizes: ½" through 30"
Pressures: 125 through 800 psi.

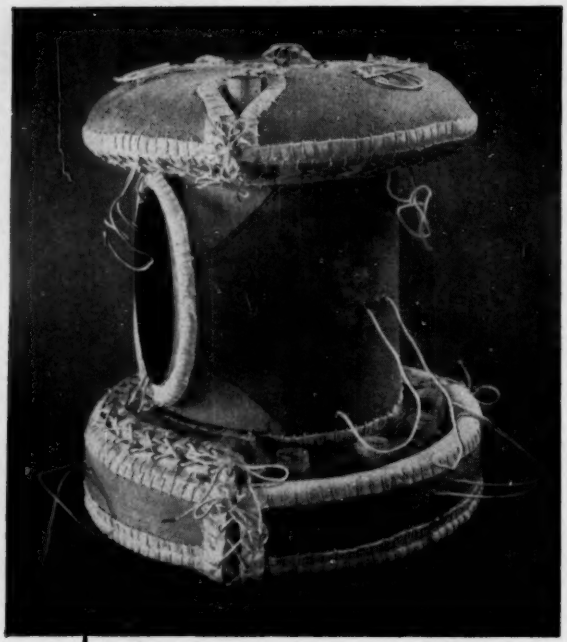
W-K-M

DIVISION OF ACF INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS

6007

BEFORE

Mockup of large stainless steel valve.



AFTER

Specially designed and tailored Glas-Col heating mantle in place on valve.

Glas-Col tailors special heating mantles for complicated applications

PROBLEM: A processing plant desired to obtain an extremely high vacuum within a large valve similar to the mockup shown above. Heat was required to remove adsorbed moisture from the inner surface of the valve.

SOLUTION: The processor built a mockup of the valve and shipped it to Glas-Col Apparatus Company. Glas-Col engineers designed and tailored a special 650°C electric heating mantle for the valve.

RESULT: The high vacuum was obtained with no difficulty whatsoever.

If you have a heating problem that calls for a heating mantle of unusual design and shape, call on Glas-Col . . Glas-Col has tailored thousands of special mantles. Glas-Col Apparatus Company, Dept. CR 711 Hulman Street, Terre Haute, Indiana.

Here are other specially tailored Glas-Col heating mantles of unusual shape:

. . the world's largest manufacturer of heating mantles

GLAS-COL ELECTRIC HEATING MANTLES

Trademark Registered U.S. Patent Office

U.S. Patents . . 2,282,078 2,739,220 2,231,506 and 2,739,221

Acetic Acid
Acetates
1. Ethyl
2. Isopropyl
3. Amyl
4. Butyl
Acetone
Alcohol, Ethyl (grain)
Alcohol, Methyl (wood)
Alum (paper mill)
Aluminum Sulphate
Acid Mine Water
Aluminum Hydroxide
Ammonium Chloride
Ammonium Bicarbonate
Ammonium Nitrate
Ammonium Sulphate
Ammonium Phosphate
Asphalt
Asphaltum
Aromatic Hydrocarbons
1. Benzene
2. Benzol
3. Cyclohexane
4. Xylol
5. Xylene
6. Toluene
7. Napthalene
8. Hexane
Barium Chloride
Barium Hydroxide
Barium Nitrate
Barium Sulphate
Beer
Benzene (coal tar product)
Benzine (petroleum product)
Bichloride of Mercury
Beet Sugar Liquor
Beer Wort
Black Liquor
Brine, calciu
Brine, sodiu
Boric Acid
Bordeaux Mi
Boiler Feed W
Carbon Bisulfi
Carbon Tetrachl
Carbon Disulphide
Carbon Dioxide
Carbonic Acid
Carbolic Acid

Calcium Brine
Calcium Chloride
Calcium Acid Sulphate
Calcium Chlorate
Calcium Hypochlorite
Calgon (sodium hexametaphosphate)
Chlorinated Hydrocarbons
1. Carbon Tetrachloride
2. Tri Chloroethyline
3. Ethylene Dichloride
4. Methyl Chloride
5. Propyl Chloride
6. Chloroform
7. Dichloroethylene
Castor Oil
Caustic Potash
Caustic Soda (lye)
Caustic Zinc Chloride
Cellulose Acetate
Cellulose Nitrate
Citric Acid
Clay Slip
Coal Tar Oil
Coal Tar Solvents
Copperas
China Wood Oil
1. Drying Oils
2. Vegetable Oils
Chromic Acid (diluted)
Copper Nitrate
Copper Sulphate
Creosote
Cyanide
Corn
ed Oil
ue of Potassium
Distilled Water or Deionized

Diethylene Glycol (alcohol)
Diethylene Glycol (monoethyl ether)
Distillery Wort
Edible Oils
Epsom Salts
Ethyl Alcohol
Ethyl Acetate
Fatty Acids
Ferric Chloride
Ferric Hydroxide
Ferrous Chloride
Ferrous Sulphate
Formaldehyde
Formic Acid
Fruit Juices
Fuming Sulphuric Acid
Furfural
Fuel Oils
Fusil Oils
Gasoline
Grape Juice
Glue
Glucose
Grain Alcohol
Glycerine
Glycerol
Hydrochloric
Hydrocyanic
Hydrofluos
Hydrog
l Sulphate
cid
altum Base
ps
Kerosene
Ketones
1. Acetone
2. Ethyl Methyl
3. Methyl Acetone
Lard

Lacquers
Lime Water
Linseed Oil
Lye (Sodium Hydroxide)
Lubricating Oils
Magnesium Chloride
Magnesium Sulphate
Milk of Lime
Mine Water
Mercuric Chloride
Mercury
Molasses
Methanol
Methyl Chlori
Naphtha
Nickel
Oil—
Paints
Palmitic Acid
Paraffin (melts at 45° to 60° C.)
Potassium Carbonate
Potassium Chloride

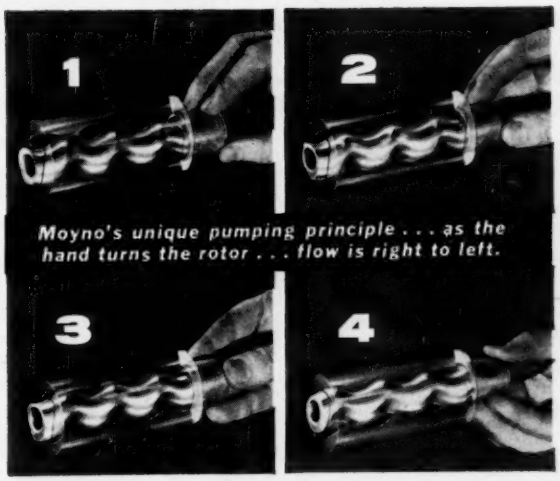
Potassium Cyanide
Potassium Sulphate
Potassium Nitrate
Pheno
Pickling
Printi
Propa
Rosin
Salammoniac
Salt Brine 3%
Salt Brine 3% to 30%
Starch
Sea Water
Sewage
Soap Liquor (thin)
Shellac
Soda
Soy Bean Oil
Sodium Bicarbonate
Sodium Carbonate
Sodium Aluminate

Propane
Rosin
Salammoniac
Salt Brine 3%
3% to 30%
(thin)
Sodium Bisulfite
Sodium Chloride (see salt brine)
Sodium Hydroxide
Sodium Nitrate
Sodium Silicate
Sodium Sulfate
Sulfurous Acid
Sugar
Stearic Acid
Tar
Tar & Ammonia in Water
Turpentine
Toluene (toluol)
Titanium Chloride
Urine
Varnish
Vinegar
Vegetable Oil
Vitriol—Blue
Vitriol—Green
Whiskey
Wine
Wood Pulp
Xylene
Yeast
Zinc Chloride
Zinc Sulfate
Zinc Nitrate

MOYNO®
CHEMICAL PUMPS

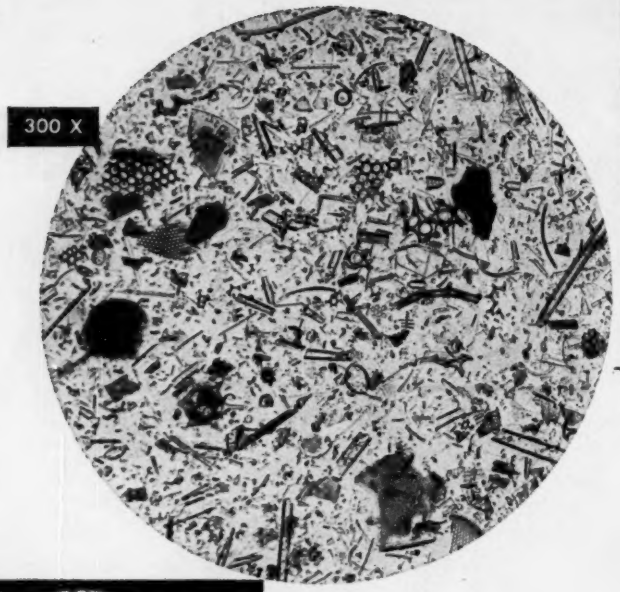
Abrasives, corrosives or suspended solids...a MOYNO® *will pump it!*

Moyno pumps are successfully handling all the substances listed above, and many others. Makes no difference whether these are thin watery slurries, non-pourable abrasives, gnawing corrosives or suspended particles up to 1⅛" dia.—Moyno will pump it! The wide range of specially-resistant materials in which Moyno pumping elements are available assures exact job-tailored design for economical handling without excessive pump wear. Moyno's single rotating part provides positive displacement . . . delivers uniform discharge without pulsation, agitation or turbulence. Moynos are available in nine sizes with capacities from 1/100 to 500 gpm and pressures up to 1000 psi. Let Moyno cut your pumping costs! See product information in *Chemical Engineering Catalog* or write today for new Bulletin 100-CE!

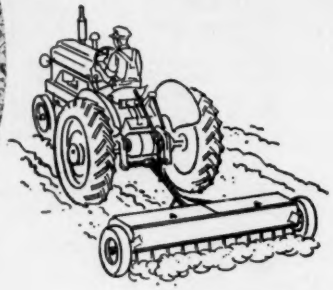


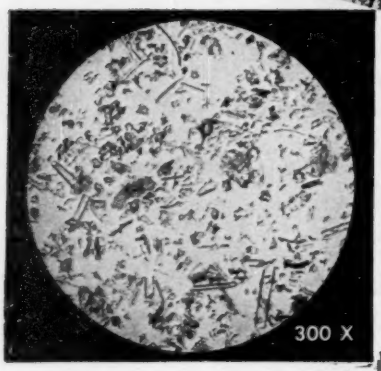
ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

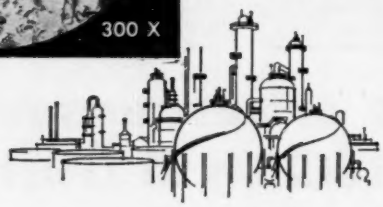


For fertilizer coating—Celite 379, a natural milled diatomite, provides the uniform conditioning needed to prevent caking of granular, mixed or prilled fertilizers—maintains good free-flow characteristics even after prolonged storage.





For catalyst carriers—Super Floss, finest particle size flux-calcined Celite grade, is used where a non-reactive porous silica support is needed. (Also available: special Celite supports in many preformed shapes for strength, high temperature stability, resistance to abrasion and attrition.)



As a paint-flatting agent—Celite 281, air-floated fines of flux-calcined diatomite, provides uniform and efficient flatting at low cost. Contributes to control of low angular sheen, durability, and faster drying.

In diatomites, Johns-Manville precision processing works for you

Celite diatomite absorbs its own weight of liquid . . . yet stays 'dry'

No matter which of the many available grades you choose, you can depend on a given volume of inert Celite* to retain its typical dry-powder characteristics even after absorbing its own weight of liquid.

Actually, Celite can absorb a total of more than twice its own weight. That's because a mass of the fine skeletal particles is approximately 93% air space or voids. Yet, in spite of this very high porosity, Celite is essentially non-hygroscopic.

Other unique properties—extremely high bulk, irregular particle shape and large available surface area—ideally suit Celite to hundreds of mineral filler applications. It is produced with precision from the world's purest commercially available diatomite deposit. It offers a wide choice of grades, each carefully controlled for complete uniformity.

For technical data on specific mineral filler or filtration problems, talk to your nearby Celite engineer. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

*Celite is Johns-Manville's registered trademark for its diatomaceous silica products

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EST. 1903

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MANUFACTURERS OF INDUSTRIAL FINISHES • MAINTENANCE PAINTS

Phone 8-8631 *P.O. Box 36, Williamsport, Pa.*

"we are pleased to report"

Mr. G. H. Morehouse
President
Morehouse-Cowles, Inc.
1150 San Fernando Road
Los Angeles 65, California

Dear Mr. Morehouse:

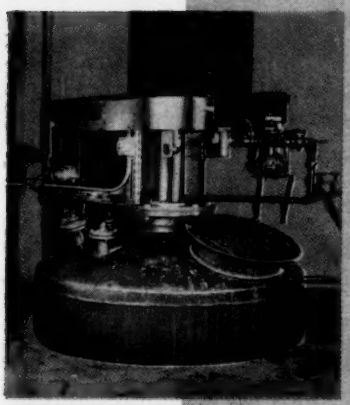
Information pertinent to our Cowles Dissolver sealed tank, thru-the-floor installation is as follows:

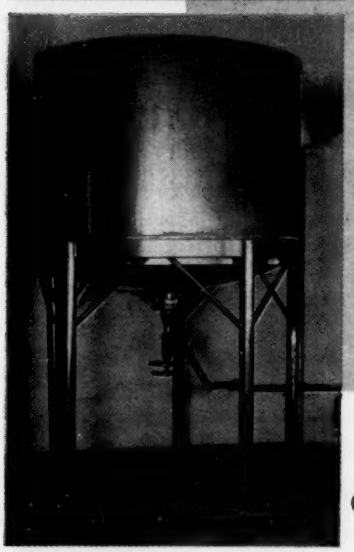
This equipment was installed primarily to manufacture cellulose acetate lacquers for exterior coating of flash bulbs. These lacquers are very viscous and are subject to excessive haze if improperly dissolved. Preliminary laboratory work, using a Cowles Dissolver, indicated that the unique "pressing type" action peculiar to Cowles would produce a solution displaying a *greater degree of clarity and freedom from haze* than any other method of dispersion. This phenomenon has been borne out by the plant installation. We are further pleased to report that we can accomplish the desired solution characteristics in *one-half the time required by conventional dissolving methods.*

This same equipment was found to produce *high quality* furniture and cabinet lacquers and sanding sealers in a very minimum of dissolving time and at *lower operating cost* than conventional methods.

We are further delighted with the *simplicity* of design which lends itself admirably to *easy, efficient cleaning. The variable speed control feature is still another* "plus" feature of the Cowles in that it affords us a *maximum of formulation flexibility.*

Sincerely,
GLOBE PAINT WORKS, INC.
(Signed) Paul A. Blachman, Technical Director





Cowles Dissolver Model 8-TV mounted on permanent tank, "thru-the-floor" to save space and facilitate gravity flow in factory of Globe Paint Works, Inc., Williamsport, Pa. Variable speed—500 to 1200 R.P.M., 19" impeller, 40 H.P. motor. Aluminum vessel is 100" deep x 80" dia., 1500 gal. capacity, sealed against fume leakage and also sealed in floor to eliminate possible fire hazard from either level.

629

Let us demonstrate the advantages of a Cowles Dissolver in your plant at our risk. Write today for more complete information: Morehouse-Cowles, Inc., 1150 San Fernando Road, Los Angeles 65, California.

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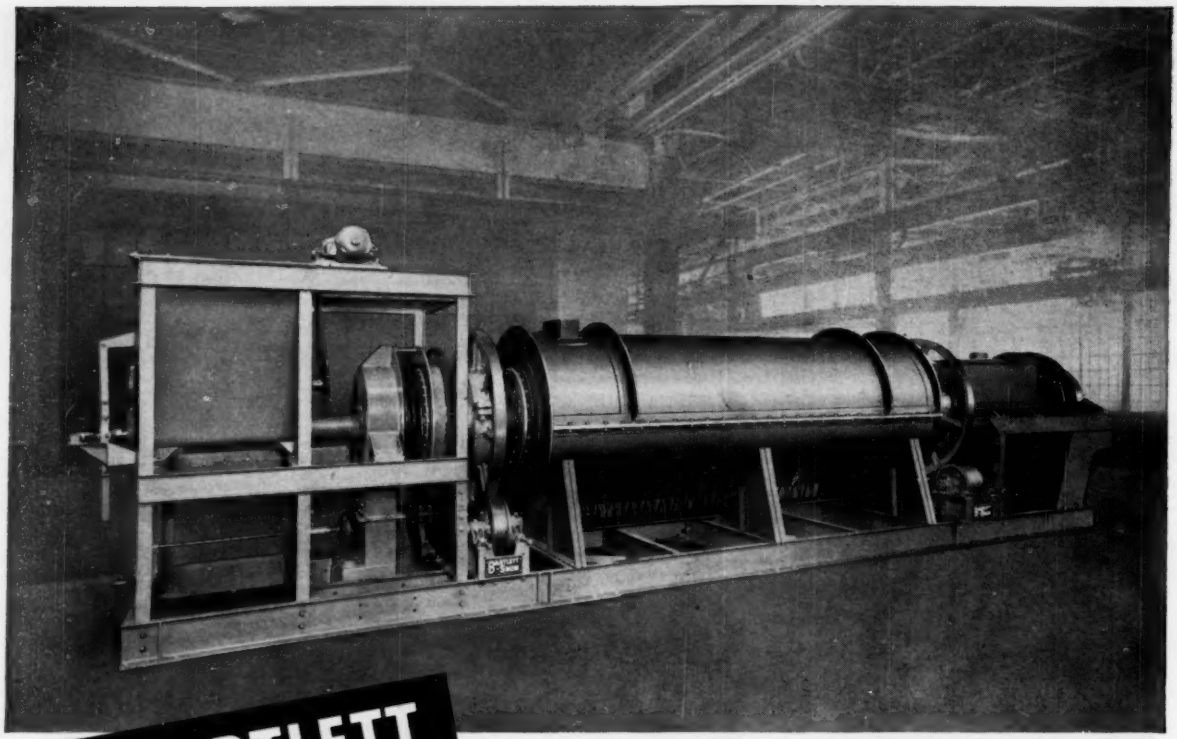
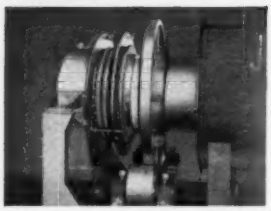


BARTLETT-SNOW CLEVELAND 5, OHIO

ROTARY CALCINERS



Close-up View of Breeching and Bellows Type Seal to Maintain Special Atmosphere.

High Temperature Rotary Calciner Showing Electrically Heated Furnace and Integral Cooler.

...permit materials to be processed continuously at temperatures to 2100°F. in a reducing, oxidizing or neutral atmosphere, and cooled to approximately 200°F. before discharge.

Bartlett-Snow Continuous Combination Rotary Calciners and Coolers are ideally suited for processing a wide variety of materials. The entire assembly including the fuel fired or electrically heated refractory lined furnace, feed hopper, variable speed feeder, seals, and breechings are all supported on a single rigid frame to assure proper alignment and efficient, trouble-free operation. Tubes are made of special alloys as dictated by the material being processed.

Complete laboratory facilities enable us to determine the time cycle, temperature, special atmosphere and other conditions—and produce actual samples of the final product before the production unit is designed or built. Let us work with *you* on *your* next job!

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Top news stories and what they mean to CPI technical decision-makers

Chementator

Cheaper titanium pumps, valves and fittings may be on the way

Titanium is entering a new phase in its struggle to win a bigger share of the chemical equipment market. Titanium Metals Corp. of America has just announced that it has perfected a casting process that may allow as many as 100 parts to be cast from the same mold. Result: lower cost for items such as pump housings, impellers, valve bodies, fittings and pump sleeves.

TMCA calls its new casting process Impel Casting but will not reveal any details about the technique other than to say that it involves a new mold material. Conventional titanium molds are made from graphite and are usually one-shot; special graphite molds can make as many as 10-12 parts per die.

Economics of Impel Casting have not been worked out to where TMCA can pin the savings down in dollars and cents. But the firm feels that the reduction in die costs will make titanium competitive in applications where castings had previously been too costly. In casting a 12-lb. impeller, for example, TMCA found that the mold costs could be absorbed in the first nine pieces, pricing the impellers competitively with similar welded titanium assemblies.

Major question now being asked: Can a big enough market for identical titanium castings be built up to exploit the full economies of the new process? With other materials, especially plastics, bidding for applications in corrosive service, titanium still faces a stiff fight.

Food irradiation program revived, new reactor studies are initiated

After a delay of two years, the Army Quartermaster Corps is continuing experiments in use of atomic radiation to preserve food. Associated Nucleonics of Garden City, L. I., has been picked by the AEC to design a radiation research station at Natick, Mass., for the Army.

A previous experimental irradiation reactor planned for Stockton, Calif., was canceled by the Army in 1959. Stated reason for abandoning the program was that scientists were not sure that irradiated foods were safe to eat. But food researchers subsequently challenged the Army's interpretation of the test results and have volunteered to dine on irradiated food to prove their point. Main problem, the scientists say, is not toxicity but merely how to get irradiated steak to taste like steak.

The Natick research station will contain both a 1-million-curie cobalt-60 source and a 24-mev. linear accelerator. One goal: to determine which of these radiation sources is the best for food preservation. The center will cost about $1.8 million and is expected to be in operation by August, 1962.

The Army hopes that irradiation can keep food edible for indefinite periods of time. The Natick operation will determine how, and to what extent, radiation affects the taste, color and cooking characteristics of different foods.

First smog-control device bids for California's seal of approval

Universal Oil Products became the first company to seek official approval for an anti-smog muffler when it recently submitted its catalytic Purzaust system to the California State Motor Vehicle Pollution Control Board. California's new anti-smog law will swing into effect as soon as the Board finds two devices that are acceptable for installation on automobiles.

The California law states that an anti-smog muffler must reduce hydrocarbon emission in exhausts by 80% and carbon monoxide by 60%. UOP claims that in 23,000 miles of road tests in California, the Purzaust system averaged reductions of 89% and 76%, respectively.

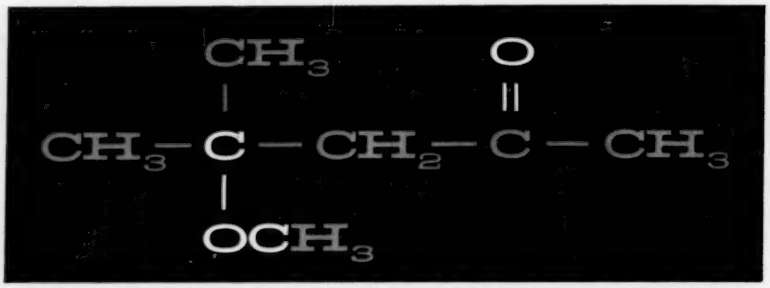
The UOP muffler shown to the press recently was pancake-shaped, about 18 in. in dia. and 5 in. thick. It contained an unidentified

BULLETIN:

Comparative data on Shell Chemical's high boiling Pent-Oxone* solvent promises lower costs on vinyl lacquers

Pent-Oxone solvent is a keto-ether. It is a remarkable new compound of this class of chemical which gives you double solvent action plus high diluent tolerance for use with a wide range of lacquer resins.

Read how Pent-Oxone solvent compares with other high boiling vinyl solvents in evaporation and viscosity, what it costs, and where it is finding new applications in and out of the coatings industry.



Solvent action in glycol ethers comes from the COC ether linkage. In ketones, the double bond oxygen does the work. Shell Chemical's Pent-Oxone is the only commercially available solvent with *both* these functional groups.

BECAUSE it combines the solvent properties of ketones and glycol ethers in one molecule, Shell Chemical's new Pent-Oxone gives you greater solvent potential than any other type of high boiler.

This potential can often save you money. In vinyl lacquers, Pent-Oxone can replace high boilers costing 40¢ to $1.10 more per gallon.

Comparative evaporation data

Pent-Oxone is in the high boiling class with an evaporation rate comparable to cyclohexanone and EGMEE acetate. Comparisons with cyclohexanone and isophorone in seconds are as follows:

Per Cent evap.	cyclo-hexanone	Pent-Oxone	iso-phorone
10%	180	231	2600
30	560	715	8300
50	940	1200	14200
70	1330	1680	20600
90	1720	2175	27600
95	1825	2310	29500
100	2120	2450	34000

Comparative viscosity data

The following viscosity comparisons are taken after one hour on a 50/50 solvent/toluene mixture with the indicated Vinylite** resin:

10% VYNS-3	Pent-Oxone	93 cps.
	cyclohexanone	54 cps.
20% VMCH	Pent-Oxone	125 cps.
	cyclohexanone	142 cps.
	isophorone	260 cps.
20% VYHH	Pent-Oxone	310 cps.
	cyclohexanone	232 cps.
	isophorone	285 cps.
20% VAGH	Pent-Oxone	500 cps.
	cyclohexanone	320 cps.
	isophorone	405 cps.

With VAGH/Pent-Oxone solvent, viscosities rise with time. This can be overcome by using 50/50 Pent-Oxone solvent/cyclohexanone as the active solvent. Such a mixture would save you 55¢ per gallon against using cyclohexanone alone.

Better odor, lower cost, many uses

The price of Pent-Oxone is 17.5¢ per pound delivered in tank cars. It can tolerate up to 70% diluent in vinyl chloride/vinyl acetate copolymer solutions. It has a better odor than other vinyl solvents and is proving valuable in vinyl adhesives as well as acrylic lacquer thinners.

In nitrocellulose lacquers, Pent-Oxone retards blush, dries in reasonable time. It acts as a coupling agent in sludge removing compounds.

Complete data and samples

For samples and information, including complete graphs on viscosity and evaporation, write or call any of Shell's 9 Industrial Chemicals Division offices, or write Shell Chemical Co., 110 W. 51 St., New York 20, N.Y.

Do it today. Start investigating Pent-Oxone's remarkable keto-ether action for yourself.

*Trade mark, Shell Chemical Company
**Trade mark, Union Carbide Corp.

A Bulletin from

Shell Chemical Company

SHELL

Industrial Chemicals Division

catalyst that is expected to last two years. Cost of the unit: about $50 more than the standard muffler it replaces.

Purzaust operates in a temperature range of 400-1,250 F., about the same as a conventional muffler. There will be about six different models, each sized to fit varying engine displacements. Weight of the unit is 10-20 lb., depending on the model. The new muffler does not develop much more back-pressure than ordinary mufflers. Manufacturing and marketing will be handled by UOP's new subsidiary, Universal Oxidation Processes, Los Angeles.

The catalytic muffler is the answer to only two thirds of the automobile smog problem, however. The other 33% of the smog-forming emissions come from crankcase blow-by. But most new cars sold in California are equipped with recycle lines that return most of the crankcase emission to the carburetor.

Longer polymer chains are key to improved polyethylene resin

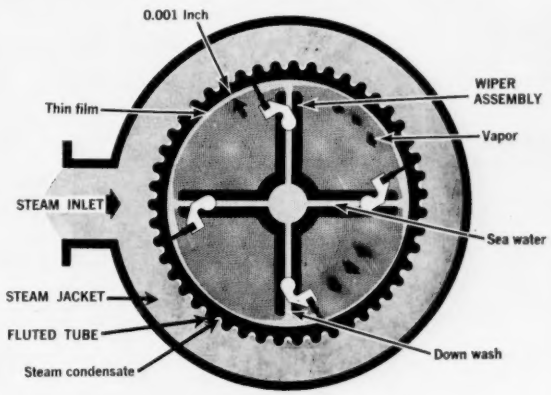
Commercial production of a new type of high-density polyethylene resin is now under way at Celanese Corp.'s Houston, Tex., plant. New facility, estimated at 10-million-lb./yr. capacity, employs a secret process that gives a resin with the same average molecular weight as ordinary PE resins but contains a higher proportion of long-chain molecules.

Advantages of the new resin, called Fortiflex R, include greater toughness, increased ease and speed of fabrication. And it offers these improved properties at no increase in resin price. Among the end products envisioned for the material are industrial and home piping, automotive and appliance parts, containers for liquids.

Although it is relatively easy to control PE's molecular weight distribution in the laboratory, the slower polymerization rates that are required on a commercial scale have made it uneconomical to produce resins with longer polymer chains. But Celanese says its new process can make the improved resin without sacrificing manufacturing speed.

The firm, which produces PE via the Phillips process (*Chem. Eng.*, Apr. 4, 1960, pp. 110-113), will not disclose any details of its new route. But it evidently involves more than a mere catalyst or temperature change. Celanese's new plant had to be designed especially to produce the resin, and a company spokesman states: "We wouldn't know how to make this material in a conventional plant."

And, despite the talk of overcapacity in linear polyethylene, another major plastics producer has just shown its faith in the high-density material by announcing a 60-million-lb./yr. plant. To be built by National Distillers, the plant at Houston, Tex., is estimated to cost $15 million, will employ the Phillips process.



Desalt sea water with windshield wipers? New GE process does it

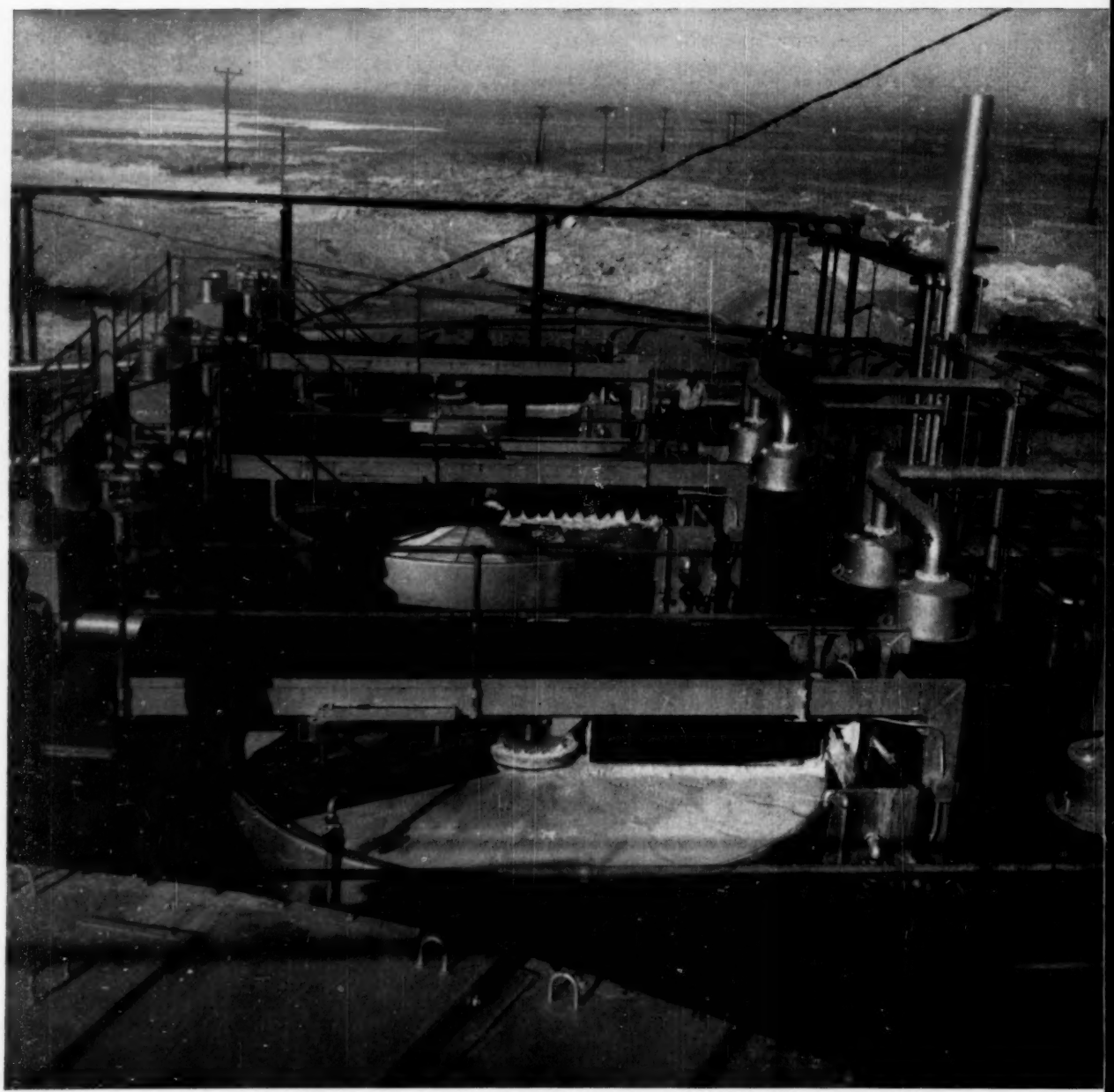
Mark up another process for extracting fresh water from brine or sea water. Developed by General Electric Co., Schenectady, the process depends on a unique distillation unit that embodies two new features.

The first is an assembly of revolving blades that, operating much like an ordinary windshield wiper, continuously spreads a 0.001-in. film on the heat-transfer surface. Result: water evaporates without boiling or bubbling, eliminating need for elaborate de-entraining equipment. Product contains only 1 ppm. salt.

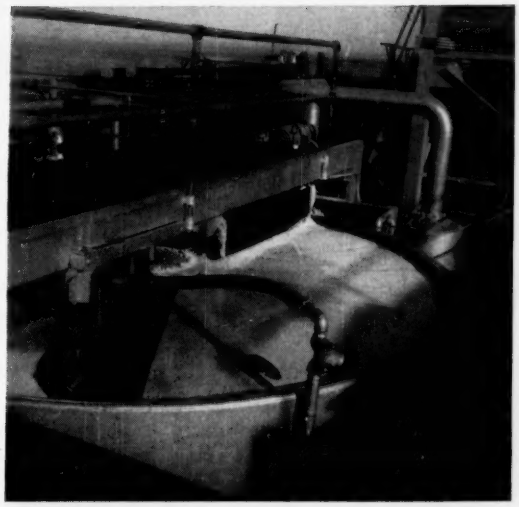
Second, the steam side of the evaporating tube is fluted (see illustration) to yield heat-transfer coefficients from four to eight times greater than those achieved in smooth tubes. Design cuts heat-transfer surface area required for a given throughput or reduces energy de-

(Continued on page 54)

Dorr-Oliver engineering



Overall view shows three of the six Oliver Horizontal Rotary Filters. These specially modified filters were selected after careful investigation showed their superiority from the standpoints of capacity and cost of operation over other type of filters tested.



Close-up of Horizontal Filter in operation. Special wash weir assembly in foreground permits flood washing of cake. The shrouded scroll discharge mechanism can be seen near the center of the photo.

and equipment aids UNIQUE SOLAR EVAPORATION PROCESS

. . . to capture additional values from nitrate ores in Chile

The Anglo-Lautaro Nitrate Corporation, producers of CHAMPION brand nitrate of soda, recently embarked on a new program involving substantially expanded recovery of chemicals based on a solar evaporation process. The process depends on solar heat to concentrate increased end liquor production from the main vat leaching cycle.

The first phase, now in operation, includes ten solar evaporator ponds of original design constructed on the desert floor. Concentration of the end liquor by evaporation from the ponds causes a primary precipitation of crude astrakanite salts which are a complex combination of the sulphates of sodium and magnesium. The precipitated salts are harvested continuously and then washed on Oliver Horizontal Filters to recover the potassium nitrate contained in the liquor that is harvested with the salts.

Large scale pilot plant investigations yielded the required design factors and two complete treatment plants are now in continuous operation. Excellence of performance may be judged from the fact that the recovery of liquor values is somewhat more efficient than was anticipated and this may be credited to the close collaboration practiced between Anglo-Lautaro and Dorr-Oliver engineers in evaluating the various aspects of pilot plant performance.

Dorr-Oliver equipment in each of the two plants includes:

- Two Dorr Bowl Classifiers, each Type DSHXB, 8 feet wide by 32 feet long with a bowl 25 feet in diameter
- One Dorr Torq Thickener, Type S-400, 120 feet in diameter
- Three Dorrco Suction Pumps, Type W, No. 6
- Three Oliver Horizontal Filters, each 15 feet diameter

For information on specific items of equipment or assistance in solving your particular processing problems, write Dorr-Oliver Incorporated, Stamford, Connecticut.

DORR-OLIVER

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mand by requiring a lower ΔT across the surface. Steam condensate runs down the troughs, leaving the crests liquid-free to maintain a high transfer coefficient.

Part of the experimental work was financed by the Navy's Bureau of Ships, part by Interior's Office of Saline Water. The device will probably get its first tryout as a fresh water generator for ships, requiring only 40% of the space and 60% of the weight called for by current units. OSW describes the process with guarded enthusiasm, indicates that if GE can build and operate the rotor assembly for a reasonable cost, the system will be very competitive with other processes.

Two cost-cutting steps would be to make the tubes without costly machining (GE says it can) and to design the unit so that incoming feed water can turn the rotor—a scheme under development. Neither GE nor OSW will quote operating costs though they are said to be competitive.

First user of Black-Clawson's Chem Preg cold-soda pulping process will be Stone Container Corp. Firm is building a 150-ton/day unit at Coshocton, Ohio, that will be on stream in a few months. Product: corrugated liners for cardboard boxes.

New superconcentrated fertilizer keeps phosphates booming

"Chemical synthesis in the fertilizer plant." That's the way a spokesman describes the latest discovery in phosphate fertilizers now being developed by the Tennessee Valley Authority at Wilson Dam, Ala. The material is ammonium polyphosphate, currently undergoing pilot tests.

Ammonium polyphosphate is made by reacting superphosphoric acid with ammonia in a pressure reactor—a new idea in fertilizer manufacture—and granulating the resulting melt. Average N-P-K analysis of this fertilizer is 15-62-0. The highly concentrated material can be mixed into solid fertilizers, or shipped as a solid and then mixed with water to form high-analysis liquid fertilizers. Economics of manufacturing this new material, however, remain to be worked out by TVA researchers.

In another area of phosphate technology, Collier Carbon & Chemical is starting up a $225,000 addition to Bunker Hill Co.'s new wet-process phosphoric acid plant at Kellogg, Idaho. The Collier plant will take a 70% P_2O_5 phosphoric acid stream from Bunker Hill, concentrate it to roughly 100% P_2O_5—about 25% higher than has ever been achieved commercially. This high-analysis material, which Collier calls anhydrous liquid phosphate, will be shipped from Kellogg to eight mixing plants for conversion into solid and liquid fertilizers.

Capacity of Collier's ALP plant is listed as 10,000 tons/yr. Commercial production should get under way late this month when the $2-million Bunker Hill plant starts making deliveries of green acid.

Process to utilize lime sludge, from carbide-acetylene production, to produce magnesia from sea water has been developed by Hokuriku Salt Industry, Tokyo. Flowsheet is employed in a new $4.3-million plant that also produces magnesium hydroxide, magnesium bicarbonate, potassium chloride, chlorine and bromine.

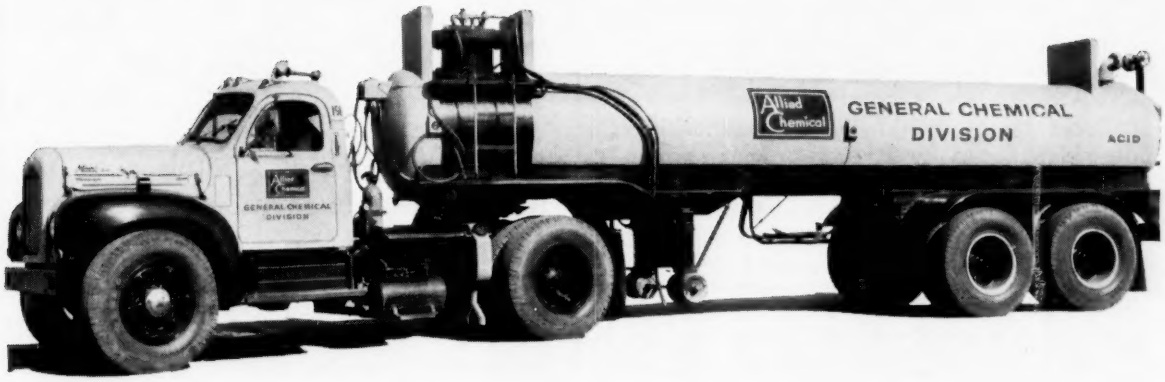
For polypropylene: new processes, new resin and fiber output

While starting up a 20-million-lb./yr. polypropylene plant at Longview, Tex., Texas Eastman disclosed that its manufacturing process is company-developed, free and clear of existing U.S. patents. Also revealed: a spare polypropylene process—another Eastman original—now in pilot-plant stage at Kingsport, Tenn.

The commercial process is continuous. Like those of other polypropylene manufacturers, it uses a two-component catalyst system. Eastman's combination consists of titanium chlorides and metal hydrides.

The alternate process is unique in that it incorporates a three-component catalyst. Third component is an organic (e.g., an amine) whose function is to increase yield of isotactic polymer.

Now... HF by Tank-Transport Delivery



Introduced by General Chemical ...The Nation's Leading HF Producer

PRODUCING PLANTS
(Anhydrous and Aqueous)
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Nitro, West Virginia
Baton Rouge, Louisiana

BULK STATIONS
(Aqueous HF, 70% only)
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Chicago, Ill.
Los Angeles, Calif.
Buffalo, N.Y.
Cleveland, Ohio

The convenience and flexibility of tank-transport delivery of Hydrofluoric Acid is now being provided by General Chemical.

This new country-wide service is being introduced with a fleet of special tank transports, each with capacity of approximately 3000 gallons (15 net tons).

Aqueous Hydrofluoric Acid, 70%, is offered for immediate delivery. Similar deliveries of Anhydrous HF can also be made available, and we welcome the opportunity to discuss your individual requirements.

For full information on this new HF service, call your nearest General Chemical office.

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GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N.Y.

Eastman predicts these uses for the 460 million lb. of polypropylene capacity planned for the U.S. by the end of 1962: 115 million lb. will go to injection molding, 200 million to film, 35 million to monofilament, 75 million to other extrusion applications, 25 million to textile fibers.

Fibers loom increasingly large in predictions for polypropylene's future. When asked recently if he thought that fiber use would equal either film or plastics uses, an Enjay spokesman's offhand retort was, "Eight times as big."

Accordingly, Montecatini has just announced that it will build a 25-million-lb./yr. fiber plant at the site of its resin-making installation at Neal, W. Va. Company asserts that it has practically solved the problem of piece-dyeing polypropylene and that its fiber price will be below the existing level of other man-made fibers.

Two firms, Aerojet-General and United Technology Corp., have both successfully fired different models of segmented solid-fuel rocket engines. Segmented engines are formed from basic fuel building blocks that are joined together in sufficient numbers to give desired thrust. Advent of these engines greatly simplifies problem of casting fuels for large solid-propellant rockets.

Senate group sees need for huge outlay for pollution control

The just-published report of the Senate's Select Committee on National Water Resources reinforces the trend that emerged from the recent national conference on water pollution: government agencies will be viewing all sources of water pollution with an increasingly critical eye (see *Chem. Eng.*, Jan. 23, pp. 78-79).

The Committee's chairman, Robert S. Kerr (D., Okla.) says that the two basic needs for effective water conservation are: (1) storage facilities to increase flow of rivers during dry spells; (2) additional municipal and industrial waste treatment facilities. By 1980, Kerr estimates, $12 billion will have to be spent on storage basins and a whopping $42 billion on waste treatment plants.

The committee recommends that the federal government, in cooperation with the states, prepare water development plans for all the major river basins. Among its other recommendations is a plea for a federally coordinated research program. This would be aimed at expediting work in such areas as evaporation control, desalination and pollution abatement.

"Real" paper may stretch into disposable garments

With isotropic Clupak paper, featuring high stretchability in all directions, attended by strength, flexibility and drape, the paper industry may be warding off some of the encroachments of the textile makers.

A real paper in that it's produced not only on papermaking machinery but from conventional paper pulp, isotropic Clupak aims at many of the same heady applications—e.g., disposable garments—as do a growing list of what might be termed "pseudo" papers. The latter cross-breed papermaking technology with textile-type fibers (*Chem. Eng.*, Feb. 20, 1961, p. 78; Apr. 18, 1960, p. 104). Advantages of Clupak: cheaper raw material, eliminates binders.

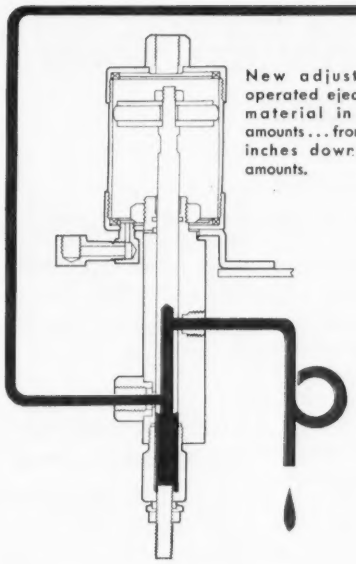
In the advanced research stage, the new product is a descendant of two-way-stretching Clupak paper. The original Clupak stretches 5% in one direction, 10% in the other. The new version stretches better than 10% in any direction, giving it not only superior resilience but also aesthetic qualities.

Clupak, Inc., developed both products and acts as licensing agent for the original, which aims at more conventional applications in competition with Kraft paper. In the two years of two-way Clupak's commercial life, list of licensees has grown to 23, at least half of whom are already producing.

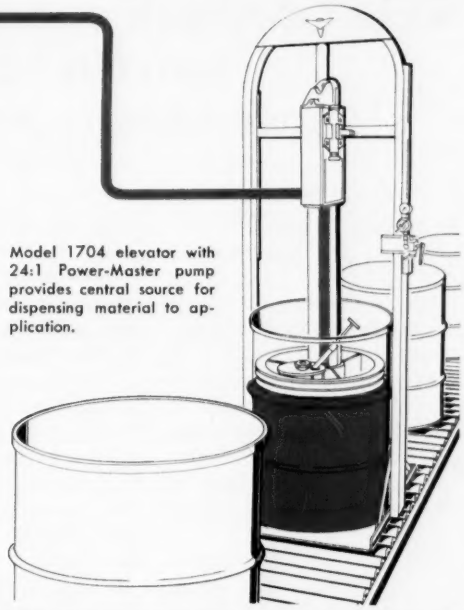
Clupak, Inc., describes process for making isotropic Clupak as a sophisticated version of the original process, which applies compressive shrinkage to Fourdrinier paper during drying (*Chem. Eng.*, Mar. 10, 1958, p. 84).

For More Industry & Economic News . . . p. 58

New ideas for dispensing materials...from LINCOLN



New adjustable air-operated ejectors deliver material in measured amounts... from 0.2 cubic inches down to minute amounts.



Model 1704 elevator with 24:1 Power-Master pump provides central source for dispensing material to application.

New technique...welding with adhesives

AIRMOTOR SIZE		2" ONE THIRD THE POWER OF THE 4"	3" ONE HALF THE POWER OF THE 4"	4"	6" TWICE THE POWER OF THE 4"
PUMP DESIGN					
SHOVEL TYPE THREE SIZES	A	25··1	37··1	75··1	····
	B	13··1	20··1	40··1	80··1
	C	8 ··1	12 ··1	24··1	48··1
BALL TYPE TWO SIZES	D	4 ··1	6 ··1	12 ··1	24··1
	E	1.3··1	2 ··1	4 ··1	8 ··1

Major automobile manufacturers now "weld" with adhesives . . . join hood and trunk assemblies with measured daubs of thermosetting mastics that adhere strongly to metal and won't slump during paint bake exposure. The "adhesive welds" save weight, prevent surface dimples caused by electric welds, absorb vibrations, and eliminate the need for asphaltic paper or other sound deadeners.

Lincoln offers complete versatility in materials dispensing equipment as shown in the pump chart at left. Simply by changing air motors or pump tubes, you get pressure ratios from 1.3:1 to 80:1. You can dispense precise amounts from gallons to ounces with Lincoln equipment.

Investigate how you can improve your production use of materials with Lincoln dispensing systems.

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Dept. CE-1
4010 Goodfellow Blvd.
St. Louis 20, Mo.

☐ Send literature on materials dispensing equipment
☐ Have local man call to discuss dispensing systems

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Company _____
Street _____
City _____ Zone ____ State _____

Industry's widest selection of materials dispensing equipment: Air-operated pumps • Measuring valves • Pressure primers • Airless spray equipment • Hose • Couplings • Air compressors • Filters • Regulators

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ENGINEERING COMPANY

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NEW ISOPRENE PROCESS...
...BRITISH PETROCHEMICAL BOOM...
...ChE ENROLLMENTS DROP

New Isoprene Process Piloted in Japan

One of Japan's leading petroleum refiners, Idemitsu Kosan, has announced that it is spearheading its drive into petrochemicals with a new isoprene plant. Firm says it has successfully produced this monomer for "natural synthetic" rubber in a 5-kg./day pilot plant in Tokuyama, on the southern end of Honshu.

Idemitsu is now designing a $11.1-million, 40,000-ton/yr. plant, with construction expected to start in late 1961. Output will be sold to Kanegafuchi Spinning and other rubber manufacturing companies. By developing its own process, Idemitsu is evidently trying to outflank three other Japanese firms that have licensed the Institut Francais du Petrole process (*Chem. Eng.*, Jan. 9, p. 35), which is also in the pilot stage.

Raw material for the Idemitsu process is isobutylene; firm will soon be producing large quantities of this material as byproduct from a naphtha cracking unit that will be built at Tokuyama this year. Few other process details are available. All the company will say is that isobutylene and formaldehyde are heated with organic catalysts until "thick"; this intermediate is then heated to free the isoprene. Idemitsu does not plan to license its isoprene flowsheet.

Process sounds similar to the IFP route, but not enough details are known about either to permit a direct comparison. IFP starts with isobutylene and an acid solution of formaldehyde to form an intermediate of dimethyl 1,3-dioxane. This is decomposed on heating to form isoprene and formaldehyde. Released formaldehyde is contacted with paraformaldehyde and recycled to the first reactor.

BRITAIN'S PETROCHEMICALS: OUTSTRIPPING OTHER INDUSTRIES

The petrochemical industry in the United Kingdom, with an average yearly growth rate of 37%, is the most dynamic factor in the British economy. So reported H. P. Hodge of Esso Export Corp. at the AIChE meeting in New Orleans last week. British investment in petrochemicals, $40 million per year, totaled about $400 million at the end of 1960.

Petroleum's share of organic chemical production in Britain has risen from 6% in 1949 to 51% in 1959, and is expected to increase to 65% by 1965. Products that have contributed to this spectacular growth are ethylene, propylene, butadiene, polyethylene, synthetic rubber, styrene, benzene, synthetic detergents and man-made fibers. Most of these were produced either not at all or in very small quantities 10 years ago. This growth has enabled Britain to build a thriving chemical export market.

Petrochemical production (thousand metric tons)

Year	Organics	Inorganics*	Petroleum Feedstocks	Investment in Organics
1957	435	130	1,280	$212,000,000
1958	475	160	1,490	$265,000,000
1959	595	245	1,850	$347,000,000
1960 (est.) ...	750	295	2,350	$395,000,000
1962 (est.) ...	1,400	300	4,290	$553,000,000

*Carbon black, ammonia and sulfur.

ChE Enrollments Drop; Advanced Degrees on Rise

Latest figures released by the Office of Education of the Dept. of Health, Education and Welfare show that 5.3% fewer bachelor's degrees in chemical engineering were awarded in 1960 than in 1959. And at the same time, total enrollment in courses leading to ChE bachelor's degrees fell off 3.5%. Thus the downtrend in chemical engineering enrollment, which started several years ago, is continuing.

The one bright spot in HEW's figures were the advanced degrees. Master's degrees increased 18.5% and doctorates climbed 19% over 1959. Here is a breakdown of the HEW statistics for 1960: ChE bachelor's degrees awarded, 2,966; master's and other predoctoral degrees, 707; doctorates, 170; total enrollment toward bachelor's degree, 17,210; enrolled for master's, 2,071; for doctorate, 972.

Although it would appear from these data that the advanced degrees are getting more popular, the steady drop in ChE enrollments must be taken into account. Before a drop in freshman enrollment shows up as a drop in master's and doctor's degrees, there is a lag-time of at least five and seven years, respectively. There is already a drop-off in enrollment for master's degrees, and it is predicted that a similar downtrend in candidates for ChE doctorates will show up by 1963 unless increasing percentages of students go on for advanced degrees.

LUBES ANTICIPATE SPACE DEMANDS

Sounding like they're from "outer space" themselves, are lubrication techniques now being researched* to meet upcoming demands of rocket engines and flight-vehicle power.

At the frontier of lubricants research, efforts now focus on finding means of operating at the elevated temperatures generated by electric power systems for such future flight vehicles as Dyna-Soar, as well as long- and short-duration satellites.* While these ultimate temperatures range from 500-1,800 F., the upper limit of fluids used in present jet aircraft is only 500 F.

Flight-vehicle power systems requiring lubrication are of the mechanical conversion type and fall into two categories, both with respect to type and application.

▶ **Closed-Cycle Systems** — First, there is the closed-cycle type, designed for long-duration satellite and space-vehicle applications. Here, the working fluid (for example, mercury, aluminum bromide, potassium or rubidium) is vaporized in a heat source such as a nuclear or solar boiler.

The hot vapor is then expanded to drive a turbine that directly powers an electric generator. Exhaust vapor is condensed in a heat exchanger or radiator and pumped back into the heat source.

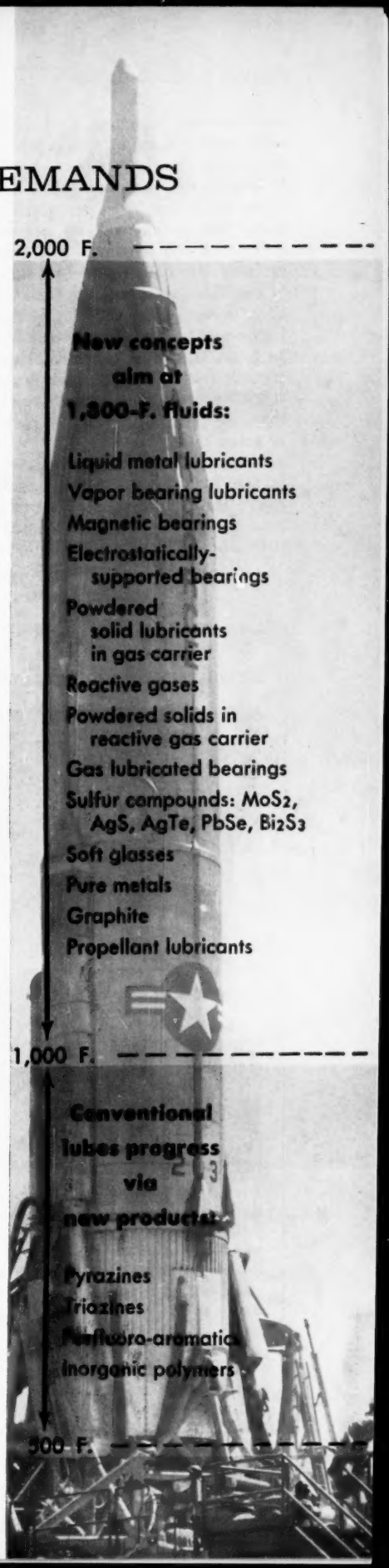
Unless dynamic seals, that have essentially zero leakage rates for long durations are utilized, a conventional oil lubrication systems is prohibited for this type of equipment.

One feasible method for providing bearing lubrication: use of the working fluid itself as the lubricant. A small portion of the liquid phase could be diverted to the bearings after leaving the pump. Temperature of the liquid going into the bearing would be 500-1,200 F., depending on the system design and the particular working fluid being used. Progress of research indicates that liquid-metal lubricated bearings justify optimistic belief that 10,000 hr. can be attained or even exceeded.

An alternate method of accomplishing closed-loop bearing lubrication is to utilize the vapor phase of the fluid. Some advantages: reduced erosion and wear should aid in attaining extremely long life; less cooling would be required since the bearings could be operated at approximately the same temperature as the vapor (1,200-1,800 F., depending on the fluid). Another advantage, particularly with respect to long-life operation, is that of low friction and low horsepower consumption.

There are two other lubrication schemes that may be worthy of research effort. One is magnetic bearings—that is, bearings supported by a magnetic field. Although there are operational difficulties with magnetic bearings—low load-carrying capacity and instability—there may be distinct advantages, particularly at cryogenic temperatures where power losses would be very low.

The other approach is by means of electrostatically supported bearings. These offer a possible solution to the lubrication problem associated with electrostatic generators. The high vacuum of space is an ideal environment for operating an electrostatic generator but poses a severe lubrication or sealing problem. If, however, electrostatic bearings could be used, the advantages would be obvious. Not only is an abundance of electrostatic electricity available, but the high vacuum



* This article is based on papers presented at a conference jointly sponsored by Wright Air Development Div. and Southwest Research Institute, in San Antonio, Tex., Nov. '60.

environment becomes a definite asset, rather than an almost insurmountable drawback.

▶ **Open-Cycle Systems**—In the other main type, the hot driving gases are exhausted and not returned to the system. The open cycle is normally used for short or medium durations (less than 300 hr.) in boost glide vehicles such as Dyna-Soar, high-mach ramjets such as SLAM (a supersonic low-altitude missile), or short-duration satellites requiring more power than is feasible with batteries or solar cells.

Since the hot driving gases run in the 1,200-1,800 F. temperature range, the turbine support bearings tend to reach equilibrium temperatures above 1,000 F. unless external cooling is provided. The aim, therefore, is lubrication techniques that could provide a satisfactory and practical means of operating at these temperatures and also at typical operating speeds of 20,000-60,000 rpm.

One approach, of course, is to employ conventional lubricants and provide the necessary external cooling. This technique has been used in the past almost exclusively. Although certain promising higher-temperature lubricants such as the polyphenyl ethers are becoming available, and may find applications in open-cycle hardware, need for undesirable external cooling will not be eliminated.

A method which does aim at eliminating external cooling: lubricating rolling-contact bearings with powdered solid lubricants entrained in a gaseous carrier, or the use of reactive gases, or combinations of both.

Also holding promise for high-speed, high-temperature operation is gas lubrication of bearings. This method has been receiving much more attention in recent years as evidenced by the large and growing number of companies sponsoring their own research programs (*Chem. Eng.*, Mar. '57, p. 114; May 2, '60, p. 53). Most of these programs, however, have not been concerned with high temperatures.

Ironically, one of the reasons gas-bearing lubrication becomes an attractive prospect is that the viscosity of the lubricant (gas) increases with an increase in temperature. Therefore, all other things being equal, higher loads can be supported as the temperature increases.

The remaining open-cycle power system that poses severe lubrication requirements is the positive-displacement power unit. Expanding hot gases are used to drive a piston in reciprocating motion, or a vane pump in rotational motion. The problems are caused by high-speed slipping motion and 1,200-1,500 F. temperatures. Sulfur family lubricants (MoS_2, AgS, AgTe, PbSe, Bi_2S_3) offer the most promise for a reducing (hydrogen) atmosphere. Other possible lubricant classes are soft glasses, pure metals, certain complex polymeric materials, and graphite.

▶ **Rocket Engines**—A primary lubrication requirement for liquid rocket engines is high-power transmission through the gear box of the propellant turbopump. Load transmission requirements for a typical rocket engine might be on the order of 4,000 hp. which, according to some designs where minimum gear weight is necessary, corresponds to a unit loading of about 4,000 psi. It is anticipated that future rocket engine turbopumps might be transmitting on the order of 10 times as much power (say, 40,000 hp.)

In most current designs, the oil and oxidizer are separated by an elaborate series of seals that have

Decontamination process whips up a dangerous froth

From the safety of his lead-lined cab, the operator shown in the inset at the upper left is peering through a special periscope at a piece of processing equipment undergoing radioactive decontamination. The technique was developed by General Electric to remove radioactivity from devices at the AEC's Hanford, Wash., plutonium facility so that the equipment can be repaired. (Previously, damaged equipment that was radioactive had to be buried since it was literally too hot to handle.) Decontamination procedure consists of a dip in an alkaline permanganate solution followed by immersion in a nitric acid bath. With radiation thus reduced to a safe level, workmen are able to remove the final hot spots with wire brushes and steam cleaning, prior to repair.

Germanium recovery process at Sylvania utilizes Solvay Hydrogen Peroxide

High grade germanium is recovered from scrap by the Chemical and Metallurgical Division of Sylvania Electric Products Inc. at Towanda, Pa. Solvay® Hydrogen Peroxide converts the element to its oxide from which high-purity germanium is refined.

This is another example of rapidly expanding new uses for Solvay Hydrogen Peroxide. As a primary source for this versatile chemical Solvay offers you a vast background of experience to help you in its application. Solvay technical service specialists, working in a fully equipped research laboratory, plus an experienced field staff are available to work with you. Write for details on the many uses for hydrogen peroxide and how Solvay can help you utilize it in your product or process.

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been doing a fairly good job of preventing mixing. While it would be desirable to use an oil that was completely inert or compatible with the oxidizer, no fluid has yet been found that possesses a combination of all the desired key properties: high gear load, good corrosion inhibition, good viscosity and lubrication characteristics, and good compatibility with the oxdizer.

One approach that the missile industry is seriously considering: utilization of the actual propellants themselves as the lubricant. This technique is currently being employed in certain hardware development programs using liquid oxygen and liquid hydrogen as lubricants. Rocketdyne, division of North American Aviation, is also testing nitrogen tetroxide, hydrazine, UDMH, red fuming nitric acid.

Except perhaps for working-fluid lubricated bearings, most of the lubrication techniques described above are still considered extremely high-risk areas of development. This means that conventional lubricants are still going to be urgently needed and widely employed in many applications for a long time to come. And research to make these lubricants meet the challenge of higher operating temperatures and other severe conditions is being intensely carried out.

▶**Stretching Conventional Lubes**—The two specifications covering presently used turbojet lubricants are for usable temperature ranges of –65 to 300 F. and –65 to 425 F. These are fulfilled by a range of dibasic esters and by two complex esters of dimethylol propane, respectively. Current research and development effort is soon expected to yield a fluid capable of standing 500-600 F. for extended time periods.

To meet more-distant goals: the pyrazine class is expected to yield compounds oxidatively stable to 600 F. with thermal stability in the 800-950 F. range. The triazines, too, are promising candidates. Polymer structures based on them —somewhat analogous to the polyphenyl ethers (*Chem. Eng.*, Jan. 25, 1960, p. 62)—are envisioned.

The perfluoro-aromatics are another chemical class under consideration. Hexafluorobenzene is one of the most thermally stable organic compounds known. Therefore, its analogues are expected to be thermally stable and this type of structure is extremely oxidatively stable. Methods for making hexafluorobenzene more efficiently are now being sought.

Theoretically, inorganic polymers represent the ultimate in thermally stable fluids, with reasonable liquid ranges, that could be used as lubricants and power-transmission fluids. However, much work is still required to yield usable materials.—FA

Resins Up Cotton Use; Cotton to Reciprocate

Cotton consumption was at least a million bales higher last year than it would have been if easy care cottons had not been available, textile scientists were told at the ninth annual Chemical Finishing Conference in September.

Frank McCord, National Cotton Council market research director, said that in 1959 cotton fabrics accounted for about 63% of the total production of easy care fabrics.

Resin finished cotton production increased from 600 million linear yd. in 1955 to 1.9 billion in 1959, and the trend is still upwards.

Rayon easy care fabric production totaled 380 million yd. and was 13% of the market. Cotton-synthetic blended fabrics totaled 130 million yd. and accounted for 4% of the easy care total.

McCord presented these statistics to point out that modern cottons offer a tremendous market for chemicals (see *Chem. Eng.*, July 25, 1960, p. 74). He indicated that research opportunities for new cotton properties also represent opportunities for chemicals. Among the improvements in cotton fabrics that chemical research could provide are greater warmth, higher luster, improved tensile strength and resistance to soiling.

If half the potential market for fabrics with these new properties were realized, and if the average amount of chemicals used equalled 5% of fabric weight, more than 241 million lb. of chemicals would be needed yearly, he estimated.

More Industry Votes for New Depreciation Law

In the latest of many surveys and inquiries into the matter, industry has again picked liberalized depreciation laws as the best kind of government aid in meeting foreign competition and in boosting economic growth rate.

Most businessmen are willing to give up capital gains treatment of depreciable property sales in return for a more adequate depreciation system, according to a study made by Research Institute of America.

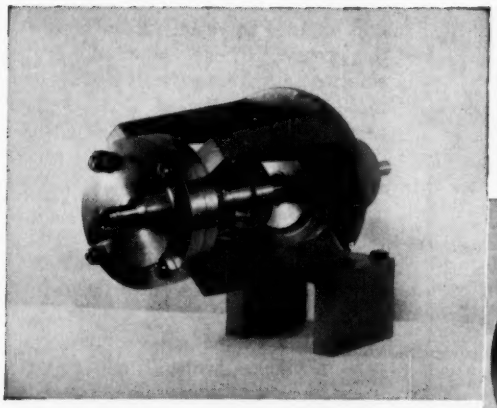
Research Institute's findings were based on replies from the organization's 30,000 members who represent a random sample of businessmen across the country. The questionnaire used on depreciation preferences was identical to the one that the U. S. Treasury Dept. and the Small Business Administration recently submitted to their own selective list of large and small businessmen. The institute's findings are being submitted to the Treasury Dept. for comparison with the results of its own sampling.

Five of every nine companies that responded to the questionnaire said that present depreciation allowances are not satisfactory. Inadequacy of depreciation was blamed equally on inflation and on the overlong "useful life" attributed to plant and equipment for tax purposes.

Eight of every 13 respondents said that they would be encouraged to expand their facilities if depreciation allowances were liberalized.

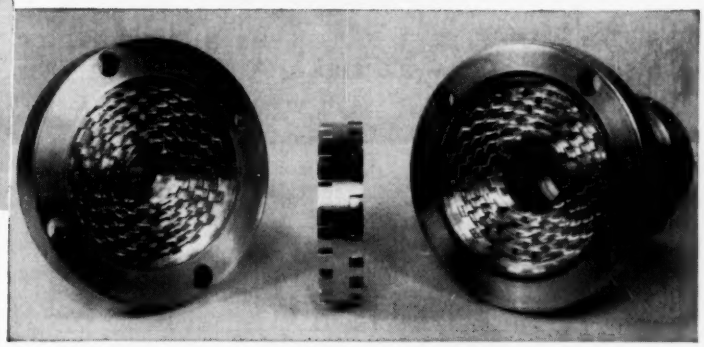
Industry witnesses testified before Congress at hearings earlier this year that American industry is burdened with $100 billion worth of obsolescent equipment and that "the inadequate depreciation allowances are falling $6 to $8 billion/yr. short of industry's requirements" to replace and modernize worn out or technologically obsolete plant and equipment.

NEW LABORATORY OAKES MIXER



Exploded view of laboratory Oakes mixing head showing stator and rotor members.

Laboratory Model 4MBH Oakes Mixer for separate motor drive. Another model is available equipped with a direct connected variable speed motor in three horsepower sizes.



For mixing any materials that will flow through pipes. For mass transfer—gas/liquid, liquid/liquid, solid/liquid. To speed chemical reactions. Available in sizes from laboratory and pilot plant up to large capacity production line models.

For the first time, a small size, continuous automatic mixer is available to the chemical industry. The Oakes Mixer, used for years in the food and foam rubber industries, can now be applied to chemical industry processing problems to provide the economies that result from continuous mixing techniques. The new laboratory model Oakes Mixer has been expressly designed to permit experimental work on a small scale in the laboratory.

Oakes Mixers are suitable for continuously mixing all flowable materials and are especially adaptable to multiphase systems. Present installations in the chemical and allied industries, in multiphase liquid/liquid applications, are producing paper coatings, photographic emulsions, polyvinyl acetate and polyvinyl alcohol.

Many Oakes Mixers have been in service for years in gas/liquid applications, producing plastisol foam, adhesive foam, polyester foam and natural and synthetic foam rubber, etc. Laboratory models are being used for experimental work with amino-formaldehyde foam, polyurethane foam, plastics and other chemicals.

Oakes Mixers are constructed of stainless steel, are exceptionally easy to dismantle and clean, and their simplicity of design makes them extremely trouble-free in operation. They are available in four models ranging from Model 4M for laboratories and pilot plants up to Model 14M for high quantity production.

Test facilities are available at our plant for the purpose of determining the increased efficiency and improved results of employing an Oakes Mixer and for testing new products and applications. Oakes Mixers are also available for investigations in your own plant under actual production conditions.

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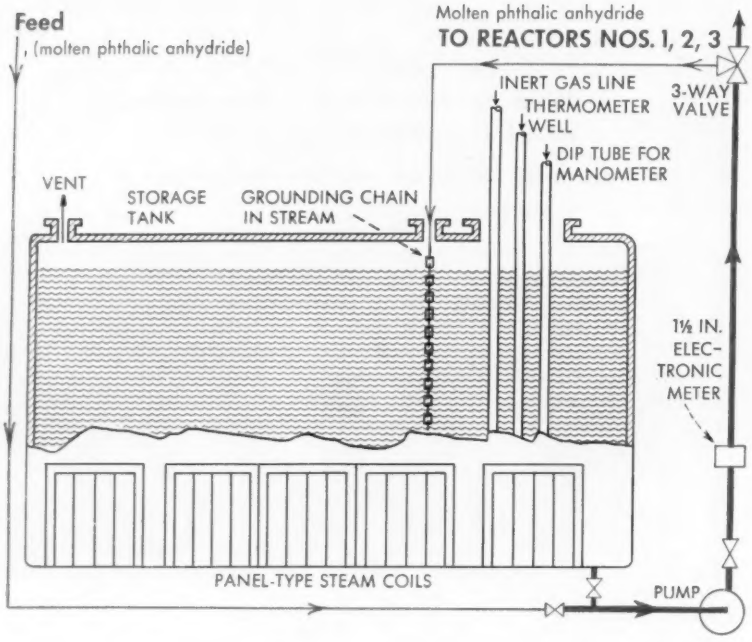

Temperature-controlled liquid-handling system for phthalic anhydride eliminates manual operations, cuts retort loading time.

Switching from a solid ingredient to a liquid one usually brings a number of benefits. And such was the case when Deecy Products Co. (div. of Reichhold Chemicals, Inc.), Cambridge, Mass., installed a new system for handling molten phthalic anhydride.

Used in the manufacture of phthalate plasticizers, the product was formerly received as flakes in 80-lb. bags. Each bag had to be moved to the reactors, cut open and dumped manually. Now, the molten anhydride is received by tank truck, stored in a steam-heated tank, and metered as needed to the individual reactors.

Representing a low (less than $25,000) investment, the new system requires a minimum of space, is highly accurate (varied only 100 lb. from tank measurements after 2 million lb. had been metered), and provides a tight system that eliminates the possibility of contact between water and the anhydride. Obviously, labor costs were also reduced.

▶**System Detailed**—The new system comprises: a 10,000-gal. storage tank; 1,500-lb./min. steam-jacketed pump, electronic meter, necessary valves and piping.

The storage tank is of standard carbon steel, insulated with rock cork. Five panel-type steam coils are mounted on the bottom third of the tank's outer surface, providing about 135 sq. ft. of heating surface. These are operated at sufficient steam pressure to maintain the anhydride at 290 F.

Heart of the system is the electronic meter. It consists of a small rotor that houses a permanent magnet and is free to rotate in a flanged section of pipe.

On the outside of the pipe is a pickup coil that produces an electric impulse for each revolution of the rotor. These impulses are counted electronically and registered mechanically on a dial. A predetermining device is included for presetting batch quantities. When desired quantity has been metered, the pump is stopped.

Valves are lubricated plug types. Piping is 2½-in. Type 304 stainless, schedule 5. A single, parallel copper tracer (⅜ in. O.D.), with heat-conducting cement, is used on all piping. Valves, strainer, meter and pump head are also steam-traced.

A series of thermocouples give temperatures at various points in the system. A well-type manometer is used to show liquid level of product in storage tank at all times and an inert gas atmosphere automatically replaces the anhydride pumped from storage.—AVG

How Much Stainless Steel For Process Equipment?

Projections on the use of stainless steel in chemical industry equipment through 1967 appear in a new market research study, made by International Nickel Co. Also, a separate study has been made on its use in pulp and paper equipment.

Each shows the particular industry's stainless steel consumption for the years 1947 and 1957, as well as an estimate for 1967, in 87 important local market areas.

The studies place total 1967 sales of stainless steel at 1.112 million tons, an increase of 87% over the 592,000 tons sold in 1957. The Inco studies also indicate for 1967: carbon steel sales of about 96.585 million tons, an increase of 38% over 1957, and total alloy steel sales of 7.280 million tons, a gain of 61% over 1957.

Progress Report...

—Vinyl Acetate
—FLEXOL Plasticizer EPO
—Diethylene Glycol

Vinyl acetate-acrylate latex paint market blossoms

Today's fastest-growing market for widely-used vinyl acetate is latex paints. In 1959, an estimated 40 million pounds of vinyl acetate were consumed in making polyvinyl acetate latex paints.

CARBIDE is a basic producer of vinyl acetate, supplying the monomer inhibited with either DPA (diphenylamine) or HQ (hydroquinone).

As a basic producer, CARBIDE is continuing its studies to improve polyvinyl acetate latexes. One outstanding vinyl acetate system uses 2-ethylhexyl acrylate as the comonomer.

In latex paints, low concentrations of 2-ethylhexyl acrylate—10-20 per cent, copolymerized with vinyl acetate—give excellent internally-plasticized resins. 2-ethylhexyl acrylate not only contributes permanent flexibility to the paint film, but also improves low-temperature coalescing properties, color retention, and water and alkali resistance.

Combination tank car or tank wagon purchases of vinyl acetate and 2-ethylhexyl acrylate can bring savings in bulk prices, inventories, and time, in addition to improved latexes.

For a technical bulletin and market information on vinyl acetate, please use the coupon at right.

Top-grade plasticizer-stabilizer for vinyls

CARBIDE's new FLEXOL plasticizer EPO is a high-purity epoxidized soybean oil that is premium-grade but not premium-priced.

The principal difference between FLEXOL EPO and ordinary epoxidized soybean oils is the higher oxirane oxygen content, which assures compounders of long-term compatibility and maximum stabilization. In many instances, the amount of more expensive metallic stabilizers can be reduced.

For stabilizing purposes alone, only two to seven parts of FLEXOL EPO per 100 of resin are required. Dual use as a stabilizer-plasticizer requires concentrations from 10 to 50 per cent of the total ingredients. Normally, such primary plasticizers as FLEXOL DOP would be used with EPO.

A typical analysis of FLEXOL EPO shows 7.0 per cent of oxirane oxygen by weight. Specific gravity is slightly less than that of water. In concentrations ranging from one part in nine to one part in four, FLEXOL EPO is compatible with vinyl chloride-vinyl acetate copolymers, nitrocellulose, ethyl cellulose, cellulose acetate-butyrate (37 per cent butyryl content), polyvinyl butyral, polyvinyl chloride, and chlorinated rubber.

A technical bulletin on FLEXOL plasticizer EPO, listing typical analysis, physical properties, compatibility, and performance in vinyl films, may be obtained from your nearest CARBIDE office.

Diethylene glycol as a basic material

Most applications for diethylene glycol stem from its hygroscopic properties and its excellent solvent characteristics. It is also a starting point for many resins and plasticizers. Diethylene glycol polyesters are important ingredients in the manufacture of polyurethane foams and low-pressure laminating resins.

CARBIDE produces resin-grade glycols of high and uniform quality, batch after batch. Shipments in bulk are made by tank car or truck. A 62-page booklet lists and describes CARBIDE's glycols, their properties, and scores of applications. For a copy of *"Glycols,"* use the coupon below.

Tear out this coupon. Check the boxes on which you'd like more information, and mail to Dept. H, Union Carbide Chemicals Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N.Y.

- ☐ Vinyl Acetate
- ☐ FLEXOL plasticizer EPO
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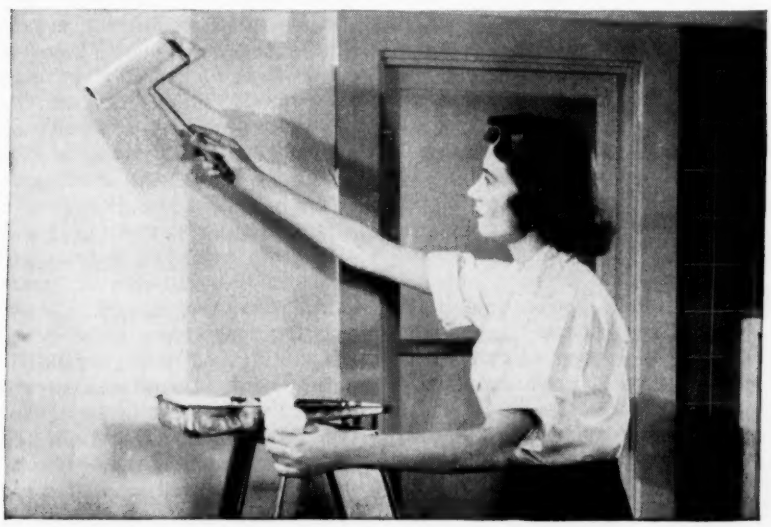
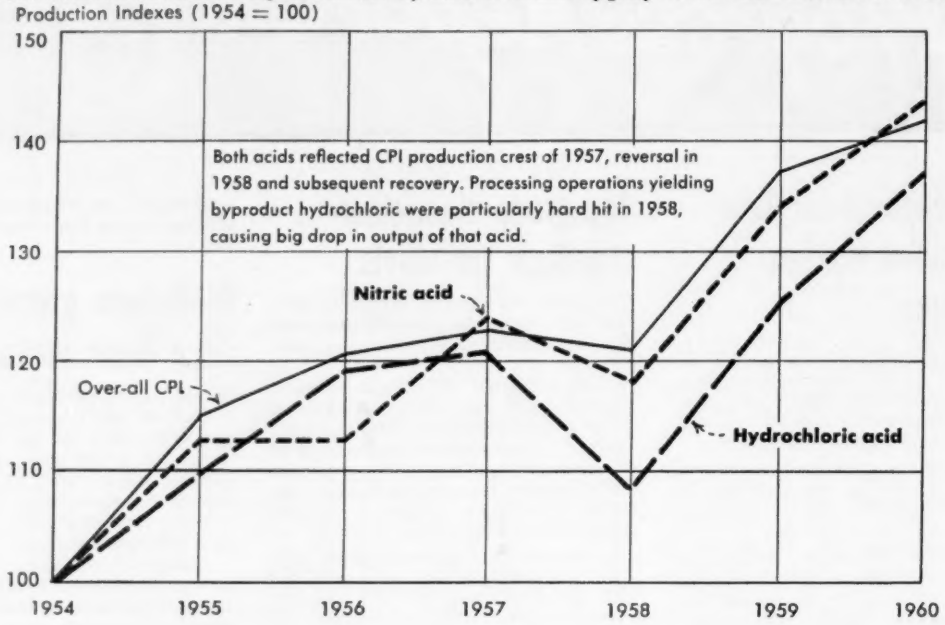


UNION CARBIDE CHEMICALS COMPANY

UNION CARBIDE

Production levels of hydrochloric, nitric acids typify over-all course of CPI



TWO HEAVY ACIDS: A CURRENT LOOK

Hydrochloric and nitric acids take the spotlight in this survey that outlines the status of each in today's technology.

Though they do not quite share sulfuric acid's acknowledged position as barometer of the chemical process industries, hydrochloric and nitric acids are both basic, large-volume inorganic chemicals. Final 1960 production figures will show hydrochloric output at about 1 million tons, nitric at around 3.3 million. And, production levels for each acid over the past several years have provided a fairly accurate trace of the ups and downs of the CPI as a whole.

Both hydrochloric and nitric acids are manufactured by a large number of producers—the Commerce Dept.'s Bureau of the Census received '59 production data from 87 plants making hydrochloric and 51 making nitric. Prices for each have remained stable since the early '50's: $30/ton for 31.45% hydrochloric acid, and $4.90/100 lb. for 94½-95½% nitric acid. Effect of this stability on hydrochloric has been to squeeze producers' margins, as labor and other operating costs have risen. In the case of nitric, the squeezing tendency has been at least partly offset by improvements in manufacturing techniques.

▶ **Hydrochloric**—Three main processes have been used for commercial production of hydrochloric acid: reaction between salt and sulfuric acid, combustion of hydrogen and chlorine together, recovery as byproduct from direct chlorination of hydrocarbons.

Data collected by the Bureau of the Census indicate that the byproduct route has been thriving at the expense of both the others. In '55, 19.25% of U.S. hydrochloric output came from the salt-acid process; the '60 tabulation will show that this figure has dropped to about 9%. Corresponding figures for the hydrogen-chlorine route are 19.1% for '55, about 16% for '60. The census bureau's third category is titled "byproduct and other" processes. But it's a safe bet that the corresponding increase in this category reflects growth of the byproduct route, because the only other commercially significant hydrochloric acid process—the Hargreaves process—is not a major factor in today's technology.

Indeed, chlorination processes yield more byproduct hydrochloric than can be advantageously marketed. Because of stream pollution considerations, it is a ticklish problem to get rid of excess, and chlorinated-products manufacturers are currently interested in techniques for recovering chlorine from the acid—thus reversing the hydrogen-chlorine combustion process.

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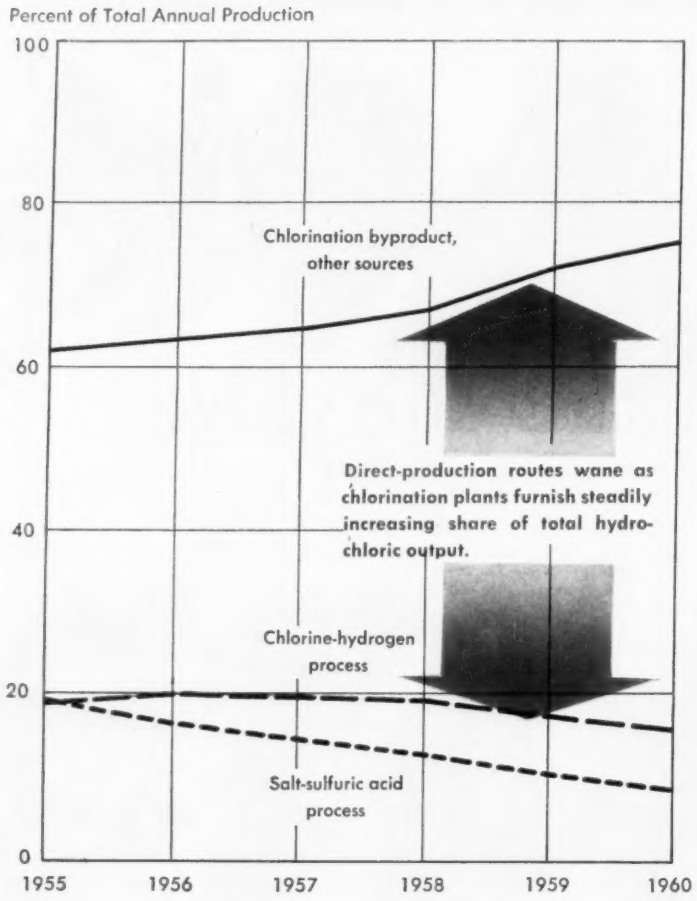
Hydrochloric acid production: a changing picture



Monsanto Chemical Co. is a current leader in this field, has successfully operated a 2-ton/day pilot plant at Anniston, Ala., for over a year to recover chlorine by electrolysis (*Chem. Eng.*, July 25, '60, p. 63). And, two other undisclosed firms are erecting similar plants in the U. S.

In a more recent development, Institut Francais du Petrole, Paris, France, has done work on a liquid-phase oxidation scheme for extracting chlorine from hydrochloric acid, based on use of nitric acid as oxidant. The institute has gathered enough data to provide the design basis for a 1-ton/day pilot unit (*Chem. Eng.*, Nov. 28, '60, p. 72).

▶**Where It Goes**—Hydrochloric acid has a diversity of established uses; major ones include activation of petroleum wells, metal pickling, sugar-cane refining, production of synthetic rubber, and manufacture of food products such as monosodium glutamate and glucose.

This list isn't likely to show significant new entries in the near future. Nevertheless, various proposed new outlets for hydrochloric acid, all of them still in embryonic stages, have drawn attention in the past few years.

Most exciting prospect—still at the research-and-development level, but under investigation by several firms—is use of hydrochloric as a supplement or replacement for chlorine in hydrocarbon chlorination.

This development, if it does pan out, will have a double-barreled effect on the hydrochloric supply-demand picture: it will furnish a new outlet for the acid, while at the same time cutting into the amount produced as chlorination byproduct. However, an industry expert points out that hydrochloric won't be as versatile a chlorination agent as chlorine, being more suitable for treatment of aliphatics than aromatics.

Two other recently announced developments cast hydrochloric as a replacement for sulfuric acid in established processes. Israel Mining Industries has come up with a wet-process route to phosphoric acid that is based on treating phosphate rock with hydrochloric. Advantages claimed over conventional use of sulfuric acid: product is of higher concentration and is purer. Process has been piloted in Tel-Aviv, Israel, and is under license to Japan's Toyo Soda Manufacturers Co. for use in a 7-ton/day plant in Tokyo (*Chem. Eng.*, Apr. 18, '60, p. 81).

And since early '59, Morton Chemical Co. has operated a 100-ton/day plant at Weeks Island, La., that uses hydrochloric acid as treating agent in making absorbent clays. Here the advantage reported over conventional use of sulfuric is that the product clay has considerably higher decolorizing efficiency. But a Morton spokesman points out that a special, undisclosed set of circumstances combine to justify the plant's use of hydrochloric instead of sulfuric. So this switch is not likely to become widespread in the absorbent-clay industry.

According to some experts, hydrochloric acid is particularly likely to find outlets during industrialization of underdeveloped countries. Reason: in such countries, chlorine-caustic demand is heavily weighted on the side of caustic, resulting in a chlorine surplus. Outlets for at least part of the surplus may be found most conveniently by converting the chlorine to hydrochloric acid.

▶**A Look at Nitric**—Most of the U. S.'s nitric acid is made by oxidation of ammonia under pressure. An older method, reaction between sulfuric acid and sodium nitrate,

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1. Standard flange with PC 50 operator.
2. Screwed end type
3. 6" flange with ST 490 operator
4. 6" flange for manual operation
5. PVC screwed end type
6. Screwed end with EM 25
7. Screwed end with PC 50 operator
8. 2" flanged valve
9. PVC flanged valve

MATERIALS:

Jamesbury "Double-Seal" Ball Valves are available in Types 303, 316 and Alloy 20 Stainless Steels, Carbon Steel, Bronze, Ductile Iron, Monel, Aluminum and PVC. Other materials on special order.

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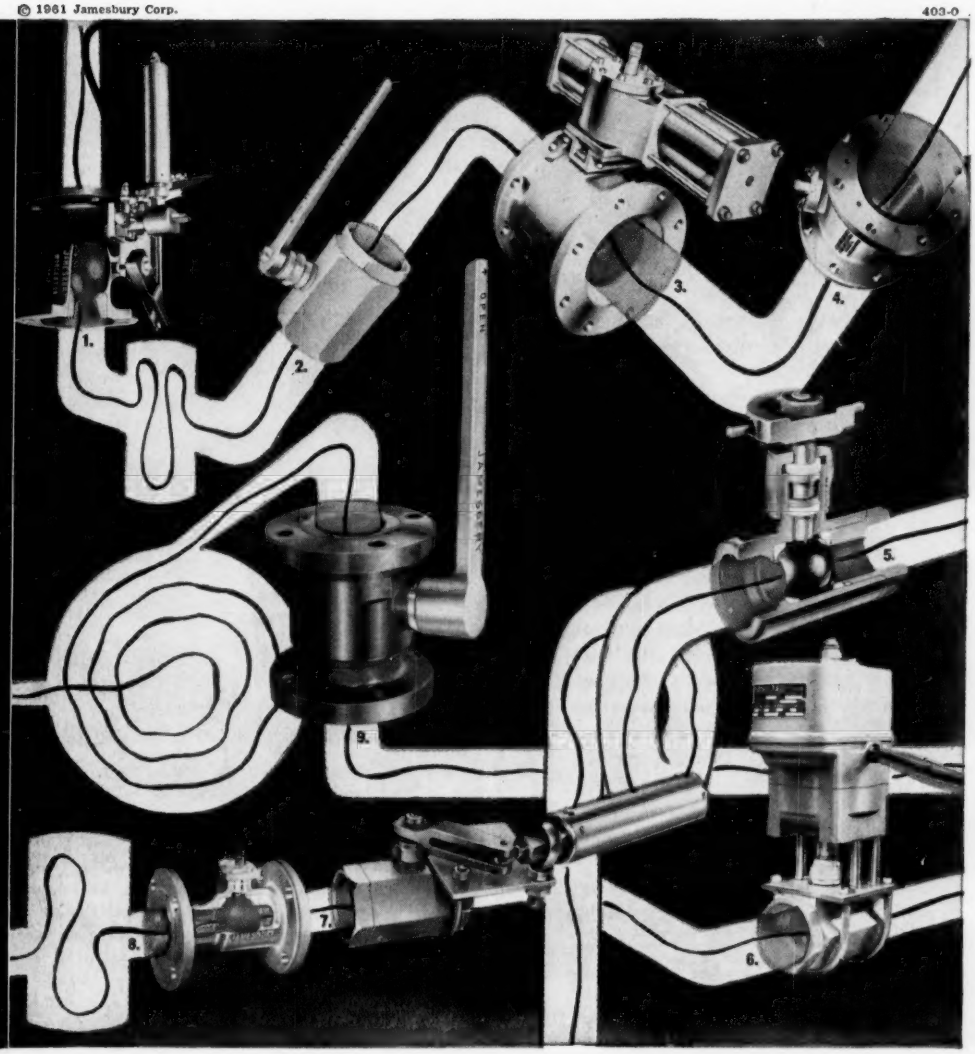
*600# series on application



Annual U. S. production: hydrochloric & nitric acids

	Short tons of 100% acid	
	Hydrochloric	Nitric
1954	763,472	2,289,297
1955	838,249	2,592,191
1956	906,348	2,592,448
1957	917,387	2,843,488
1958	826,022	2,704,062
1959	955,914	3,074,401
1960 (est.)	1.04 million	3.30 million

has receded in importance, and the much-heralded proposal to make nitric by oxidizing the nitrogen in the atmosphere hasn't yet achieved its promise.

A recent trend in ammonia oxidation technology has been to drastically lower the amount of outside power that must be supplied for compression of air feed (which is used as oxygen source). Designs of recent nitric acid plants by Chemical Construction Corp., New York, or by The Chemical & Industrial Corp., Cincinnati, for instance, have linked the air compressors with expansion turbines that recover energy from downstream gases.

A new approach to oxidation of nitrogen in air has been under study at Rensselaer Polytechnic Institute, Troy, N. Y. Described by industry experts as promising, the process accomplishes oxidation by passing air over glass fibers impregnated with radioactive uranium oxide.

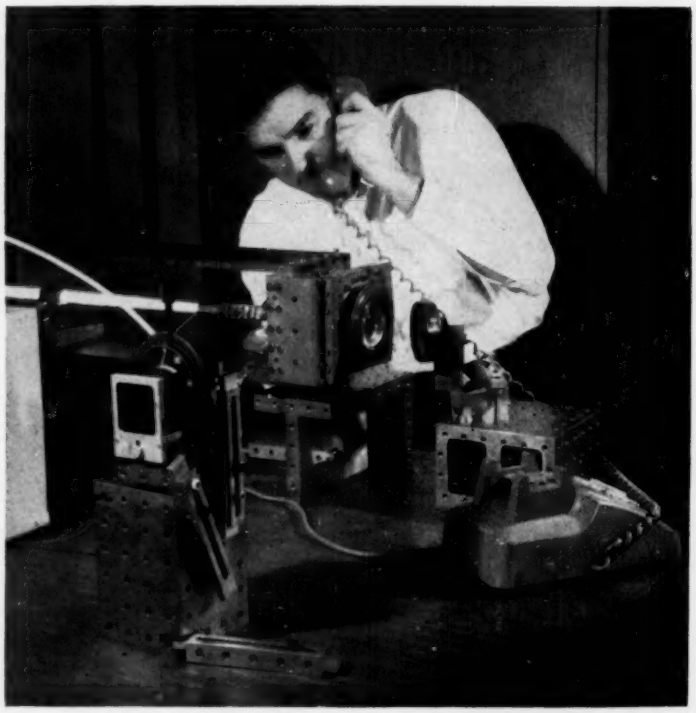
▶ **Uses**—In contrast with hydrochloric acid with its broad slate of predominantly treating uses, nitric acid finds its principal outlet as raw material for the fertilizers and explosives industries. Ammonium nitrate, a prime nitric acid product, is used in both these areas. And the acid is used on the one hand to acidulate phosphate rock for fertilizer use in processes that do away with conventional sulfuric acid treatment, and on the other hand to make explosives such as TNT and nitroglycerine.

Interest in ammonium nitrate as an explosive has heightened recently. A mixture of the salt with oil constitutes a controllable explosive that is said to be highly suitable for many industrial blasting situations. Use of the mixture may broaden the applicability of industrial explosives, thus upping demand for the nitrate and hence for the acid.

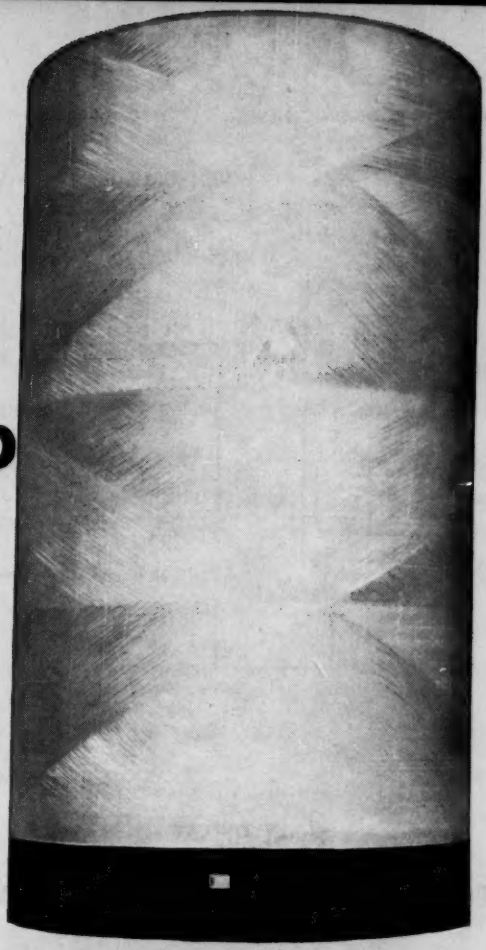
Although most trends in recent years towards higher nitrogen content in fertilizers have involved ammonia, nitric acid's participation in the fertilizers picture may be on the upswing because of a development being ushered onto the scene by American Metal Climax Inc. Company claims an economically attractive route for producing potassium nitrate, for fertilizer use, from potassium chloride and nitric acid, and will use the process in a $7-million plant now being built at Vicksburg, Miss.

Finally, government space technology may also provide a new outlet for nitric: oxidants based on the acid may win use in rockets and missiles, if corrosion, handling and other engineering problems can be surmounted.—NPC

Telephone conversation travels on a beam of light



The first potentially practical use of optical masers (Chem Eng., *Oct. 31, 1960, p. 46) has been demonstrated by Bell Telephone Laboratories. The output of the new gas maser shown above has been modulated so that a telephone conversation can be impressed on it. And unlike previous solid-crystal masers that required huge power inputs, the gas maser draws less current than an ordinary lamp bulb—and promises to be of great significance in the field of communications. The glass tube is filled with a mixture of helium and neon, generates a coherent infrared light beam that can carry many times the amount of information that can be impressed on a radio wave.*



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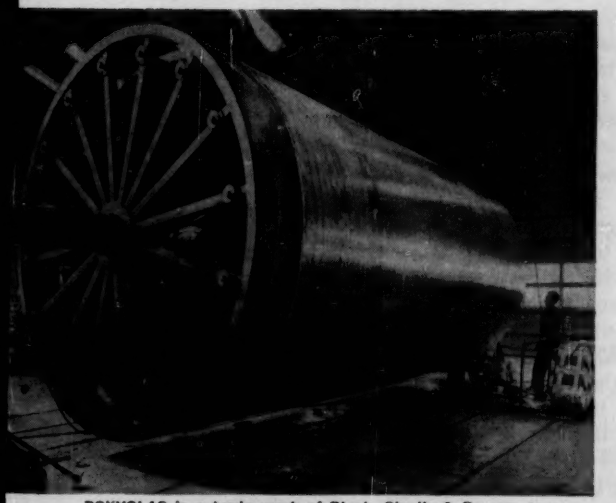

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STANDARD TANK SIZES:

NOMINAL CAPACITY (gallons)	DIAMETER (feet)	HEIGHT (feet)
4,500	10	8
9,000	10	15
12,500	12	15
17,000	12	20

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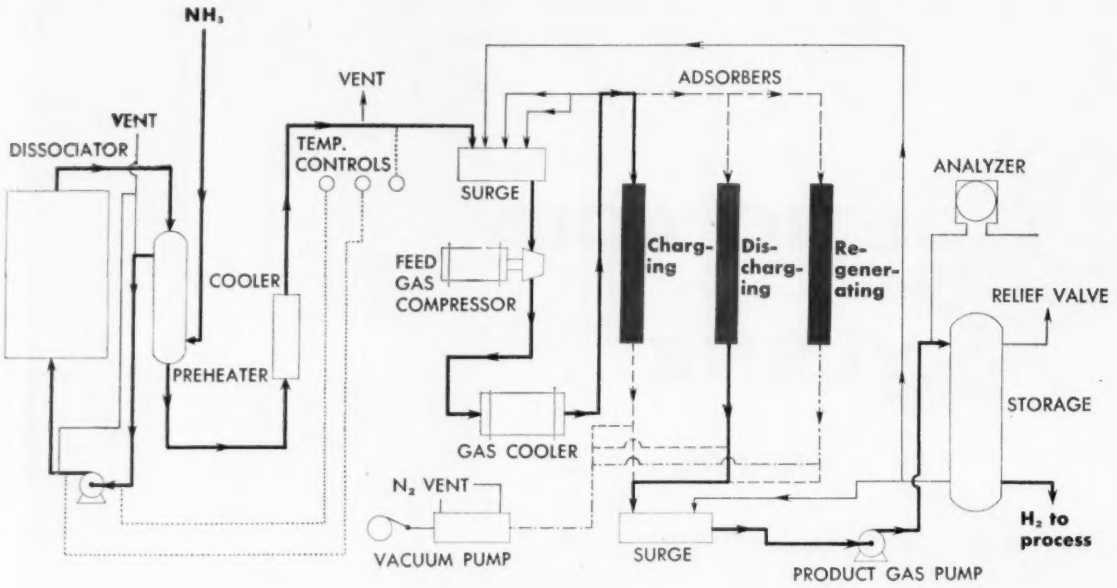
Three-stage adsorption system is key to simplified production scheme



FOR CHEAP HYDROGEN, TRY ADSORPTION

Packaged unit starts with dissociated ammonia, adsorbs nitrogen to produce hydrogen up to 99.8% pure. Yield of 95%-pure products is over 96%.

A new hydrogen generator turns out 95% or purer product from dissociated ammonia—and does it, according to the manufacturer, below the cost of equal-purity hydrogen produced in plants requiring much larger capital investment.

Using neither low-temperature distillation nor precious-metal membrane separation, the plant employs a simple adsorption process that is based on the affinity of activated charcoal for nitrogen. As each of a series of adsorbers is filled with dissociated ammonia under pressure, nitrogen is picked up by the charcoal so that when the pressure is released, the outflowing gas is predominantly hydrogen.

Developed by Armour Industrial Chemical Co., Chicago, and The Dow Chemical Co., Midland, Mich., and built by The Electric Furnace Co., Salem, Ohio, the packaged generator is ready for operation as soon as it is connected to utilities. A 2,000-scfh. plant costs about $50,000, can turn out hydrogen for about $3/1,000 scf.

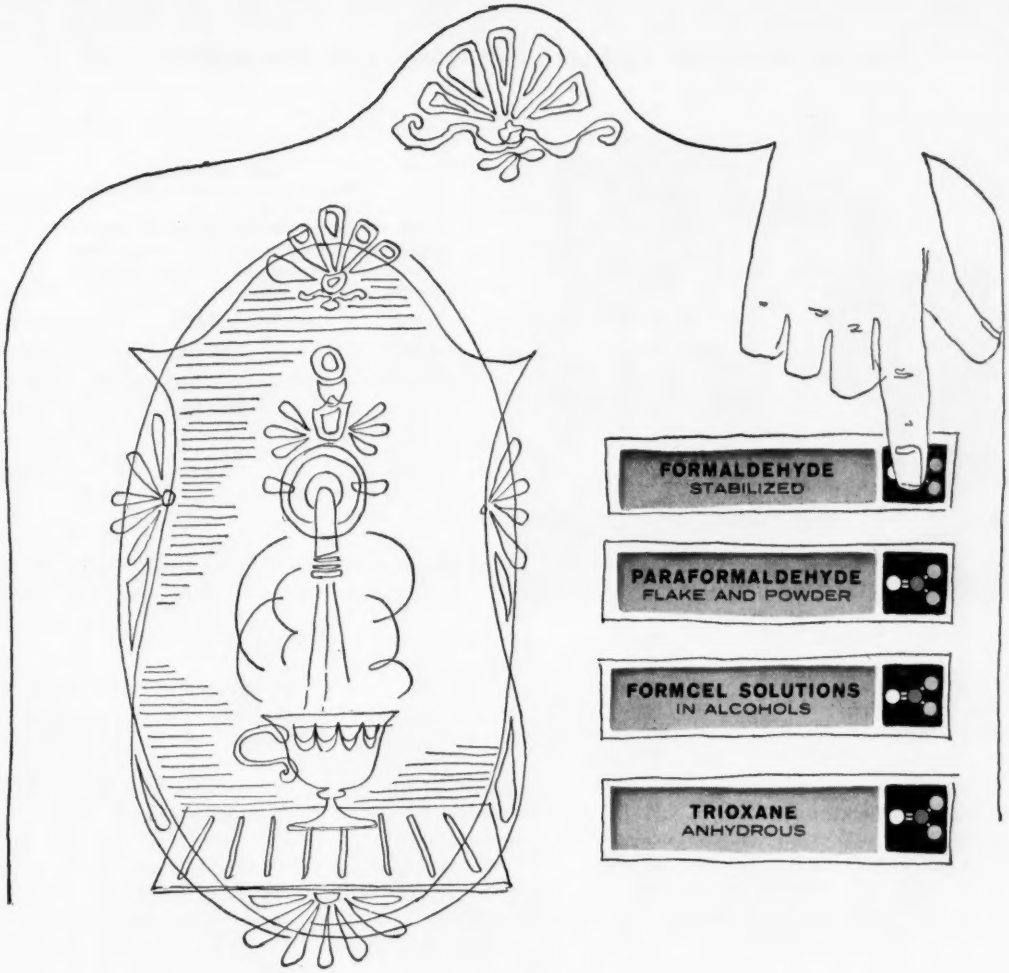
► **Makes What You Need** — The Electric Furnace (EF) plant is a versatile producer—output can be varied from maximum to 25% of capacity without loss of product quality. If demand is irregular, the plant can be started up quickly when hydrogen is needed. From a cold start to full production requires only five hours; if the dissociator is on standby, the system can begin production in ½-hr.

The two-stage operation starts with conventional ammonia dissociation by high-temperature cracking in the presence of a suitable catalyst. Dissociated product (75% H_2, 25% N_2) preheats the feed stream in a heat exchanger, is then cooled to 86 F., and delivered to the adsorption section.

Nitrogen is removed from the combined gas stream in a battery of three adsorption units. The gas is compressed to about 100 psi., cooled, and admitted to one of the adsorbers. As soon as the adsorber, which has previously been evacuated to 10 mm. Hg absolute, is filled with gas to line pressure, the inlet valve closes and the outlet valve opens, releasing product gas to a blower.

► **Charcoal Grabs Nitrogen** — In passing through the adsorber, nitrogen is rapidly adsorbed by the charcoal, then very slowly desorbed. Hence the first product released from the outlet is extremely pure—about 99.8% hydrogen.

As the pressure falls and more gas is released, the hydrogen content decreases until it reaches about 79% in a typical cycle. At this point, the product delivery valve closes, the evacuation valve opens, and a vacuum pump lowers the pressure in the adsorption bed to clean out residual gases—mostly nitrogen, with some hydrogen and



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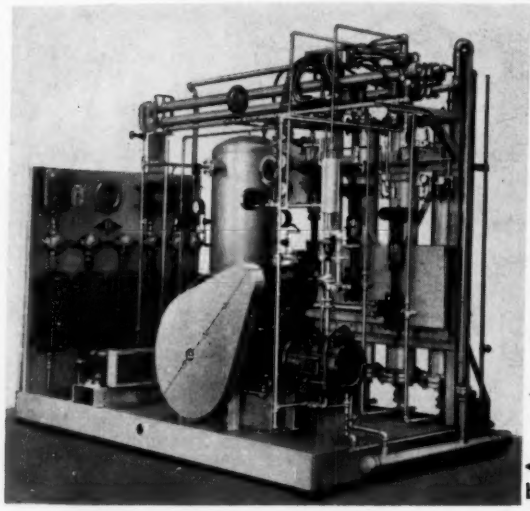
Celanese CHEMICALS

Compact design for packaged unit lowers hydrogen product price



◀ **Skid-mounted** hydrogen plant is factory assembled, ready to go when utilities are connected.

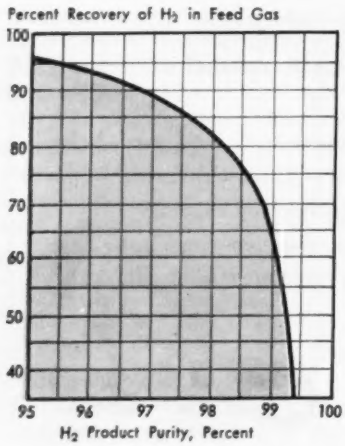
Cost of hydrogen
(Based on standard electric 2,000 scfh. plant)

Fixed cost/hr. (including interest on capital investment, maintenance, floor space rental, insurance, taxes and depreciation) based on operating year of 6,240 hr.		$1.65/hr.
Labor;	1 hr./day @ $4.50	$0.19/hr.
Power;	86 kwh. @ $0.013	$1.12/hr.
Water;	600 gal./hr. @ $0.20/M gal.	$0.12/hr.
Ammonia;	65 lb. @ $0.045	$2.92/hr.
Cost of 95% H_2 per 2,000 scfh		$6.00

a small amount of undissociated ammonia that may have come through the dissociator.

With an 80-sec. cycle for charging, discharging and evacuating, the product gas composite has a hydrogen content of about 96%. Since this includes product ranging from 99.8 to 79% hydrogen, it is easy to see how higher-purity product can be produced by increasing the cutoff pressure on the depressurizing cycle.

▶ **Purity vs. Yield** — The graph (below) depicts the effect of a change in desired product purity on hydrogen recovery. For a 95% product, better than 96% of the feed hydrogen is recovered. For 99% product, about 68% recovery is achieved. Yield plummets if higher purities are desired. In all cases, the impurity in the final product is nitrogen—with a leaktight system, there is no possibility of contamination from oxygen, and the process precludes contamination from CO or CO_2, which is possible if the process started with a different basic gas.



The system is said to require only 1 man-hr./day, hence controls are automatic. An analyzer continuously samples the product and indicates any infiltration of oxygen. If the oxygen content exceeds 20% of the lower explosive limit of oxygen in hydrogen, the system is shut down.

▶ **Pressure Control**—Product gas from the adsorbers is pumped to storage by a compressor that has ample capacity to handle fresh product while also recirculating the contents of the tank. If pressure builds up to a preset maximum, a pressure relief valve opens and hydrogen bypasses back to the dissociator.

Excessive flow from the dissociator to the compressor is prevented by bypassing gas from the discharge to the entry side of the compressor to maintain a positive pressure there. Pressure and temperature alarms are used throughout the system to close control valves and shut down the system if abnormalities occur.

▶ **Ammonia the Key**—The cost of $3/1,000 scf. hydrogen is based on the estimated cost of bulk ammonia delivered by tank car. If the price of tank-truck ammonia is used as a basis, the cost rises to about $5/1,000 scf. for 95% product. On the same basis, 99%-purity product costs about $6.25/1,000 scf. The table above breaks down the costs for the tank-ammonia, 95%-product example.

The Electric Furnace Co. has designs for plants ranging in capacity from 350 to 10,000 scf. hydrogen. Design data were obtained from The Dow Chemical Co., and from a 750-scfh. test plant built by EF. The 2,000-scfh. plant, excluding ammonia dissociator and ammonia storage facilities, is a skid-mounted package approximately 7 × 18 × 10 ft. tall.

Applications for 95% hydrogen are varied. It is used as a reducing agent for manufacture of various metals, including tungsten and molybdenum; for hydrogenation of various organic chemicals and vegetable and animal oils and fats; for reducing aldehydes to the corresponding alcohols and making hydrogen chloride and bromide.—FCP

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You can count on Powell Valves for the answer to virtually any flow control problem where corrosion, erosion, temperature, or pressure are encountered. Because, at Powell, you'll find the largest selection of valves for the chemical industry.

For instance, only Powell offers you such a wide selection of materials—both ferrous and non-ferrous. This includes Stainless Steel, Nickel, Monel*, Hastelloy#, Ni-resist* and aluminum, just to mention a few.

Powell Corrosion-Resistant Valves are also rated up to 2500 pounds W.P. and for temperatures up to 1000F. For complete information and the answer to your corrosion, temperature or pressure problem, contact your nearby Powell distributor or write us directly.

*Registered trade names of The International Nickel Company.

#Registered trade name of Haynes Stellite Company.

150-pound W.P. Tank Valve. For mounting to bottom or side of vessel. Fig. 2309, disc opens into tank. Fig. 2310, disc opens into valve. Sizes, ½" through 8". Supplied in stainless steel, Monel, Nickel and other alloys. Available on special order in other sizes and pressures.

150-pound Stainless Steel Globe Valve, Fig. 2429. Outside screw rising stem and yoke, bolted flanged bonnet, integral seat. Available only with flanged ends. Sizes, 4" through 12". Angle valves of this design can be supplied on special order.

150-pound Steam Jacketed Gate, Globe, Lift and Swing Check Valves, Fig. 2800. Made especially to control the flow of heavy viscous media that require a heated jacket to keep them fluid. Shown, a Stainless Steel Gate Valve available with guided interchangeable solid or split wedge and integral seats. Sizes, 1" through 4".

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PETROCHEMICAL BENZENE: MORE AND MORE

Startling upsurge in benzene-from-petroleum continues apace. Capacity to top 100 million gal./yr.

Benzene-from-petroleum, which was big news in petrochemical expansion plants last year, is continuing its meteoric rise to new capacity heights. Three companies—Crown Central Petroleum, Shell Oil, and Atlantic Refining-Pure Oil (jointly)—have announced new plants or expanded facilities that will boost U. S. petrochemical benzene capacity another 100 million gal./yr.

Late-1960 estimates of 193.5 million gal./yr. new capacity, which was an increase of 63.5% over the 304.5 million gal./yr. capacity already in operation, must now be revised upward to a whopping 96.5% increase—and other announcements are expected soon.

Prominent by its absence from the forecast is Universal Oil Products' Hydeal catalytic dealkylation process, selected for almost one third of the capacity represented in the 193.5 million gal./yr. "under construction or planned" figure indicated above—although Dow Chemical Co. is considering construction of a 30-million-gal./yr. Hydeal unit at Freeport, Tex.

▶ **New Process Competes**—One of the new plants will incorporate a recently announced process (*Chem. Eng.*, Feb. 20, p. 73) for catalytically converting toluene and xylene to benzene, directly in competition with Hydeal.

Developed by Houdry Process Corp., Phila., the process, called Detol (see flowsheet below), is slated to be used in a 17-million-gal./yr. plant now under construction at Pasadena, Tex., for Crown Central Petroleum Corp., Houston, and Baltimore.

Toluene feedstock for the unit will be prepared in a Udex extraction unit that will yield an additional 4-5 million gal. of benzene. Xylene product from Udex unit may be converted to benzene in whole or part depending on benzene demand.

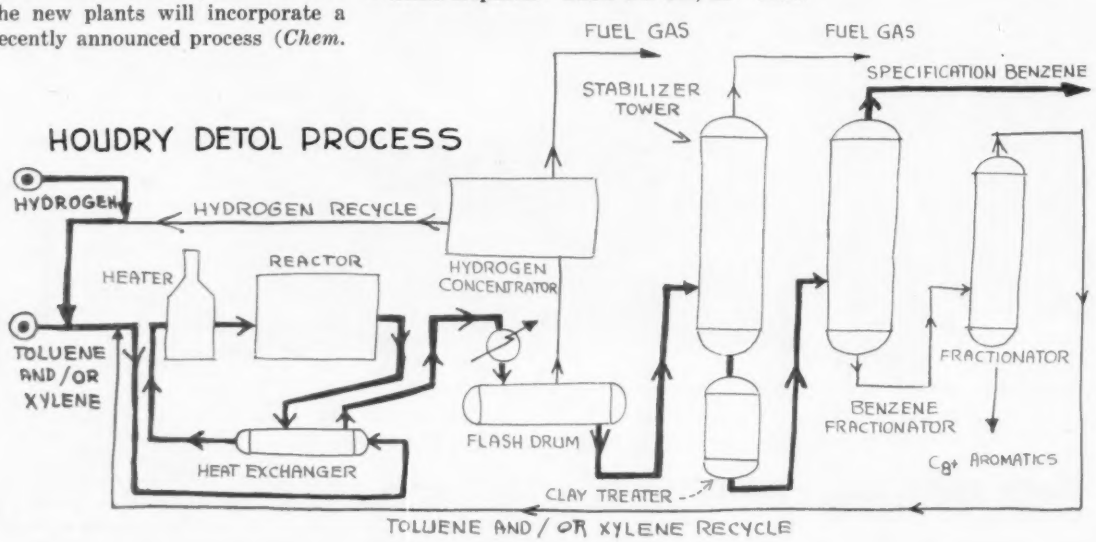
The process dealkylates toluene and/or xylenes, or alkyl benzene concentrates containing paraffins, olefins and sulfur compounds. Strong point of the process: the catalyst, said to be similar to, but cheaper than, reforming catalyst, is not affected by sulfur. Benzene product made from sulfur-containing feed streams contains less than 1 ppm. thiophene.

▶ **Shell Expands**—Shell Oil Co., in expanding its benzene facilities at Wilmington, Calif.; Houston, Tex.; and Wood River, Ill.; has become one of the world's largest producers. Total capacity is rated at over 60 million gal./yr. Shell benzene is made by an extractive distillation process that feeds on a platform reformate stream rich in aromatics.

An early pioneer in petrochemical benzene, Shell claims to have produced it commercially for the first time in 1947 and built the first plant designed specifically for benzene recovery from petroleum in 1953. The present expansion will have effectively tripled the company's capacity within the past year.

▶ **Atlantic-Pure Oil**—Atlantic Refining and Pure Oil are going into a joint venture to make aromatics in a Udex extraction unit to be built at Pure Oil's Smith's Bluff refinery near Beaumont, Tex. Atlantic's Atreco refinery on the Neches Ship Channel is near Port Arthur, six miles downstream from the Smith's Bluff plant.

Both refineries will furnish feedstock to the Udex unit, which will have a capacity of 50 million gal./yr. of mixed aromatics, principally benzene, with some toluene and xylenes. The refineries will add fractionation units to prepare the feed.



Engineers: Floyd Brown & Associates, Marion, Ohio.

Contractors: Bay Construction Company, Sandusky, Ohio.

How to Dispose of 400,000 Troublesome Gallons Daily

Getting rid of industrial waste water containing acids, cleaners, glass particles and other assorted trouble makers at Westinghouse Electric Corporation's Mansfield, Ohio, plant is a job in which LaBour pumps play an important part.

The Mansfield plant produces home appliances from toasters to ranges and washers. Pickling and plating solutions are used in substantial volume, and porcelain enameling is also done here. Resulting wastes must be treated before the water is discharged into nearby stream. There are seven LaBour pumps in the treatment plant, pumping some 400,000 gallons every working day.

Any interruption in the proper functioning of the waste treatment plant would, of course, be costly. The LaBour pumps were chosen for their known dependability and minimum maintenance requirements—good reasons why you should choose LaBours where you are responsible.

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Processes

Oxygen-refined chrome is now being produced by Union Carbide Metals at its Marietta, Ohio, plant. Oxygen refining is carried on while the metal is being treated in a standard submerged-arc furnace, allowing tighter chromium and carbon specifications, lower silicon content, and yielding a more dense product. The new technique has enabled UCM to price its improved chrome 5¢/lb. lower than the product it replaces.

Utilization of sulfuric acid residue from ilmenite leaching (in production of titanium dioxide) is described in a recent issue of *Chemicky Prumysl*, a Czech technical journal. The dilute acid (about 20% free H_2SO_4) containing sulfates of iron, manganese, titanium and other metals, is first neutralized with ammonia, which upon cooling forms crystals of ferrous ammonium sulfate that can be separated by centrifuging. Further addition of ammonia to the mother liquor precipitates iron and titanium hydroxides. The ferrous ammonium sulfate can be used to make a low-manganese ferric oxide. Iron and titanium hydroxide mixture can be calcined to yield a high-quality brown pigment.

Teflon electroplating process has been developed by Plasitron, Inc., New York. Key: a special wetting technique that allows a wide range of electroformable metals to be plated on the plastic. Process provides complete metal adhesion with no loss of Teflon's electrical properties. Possible applications in the chemical industry include plating of bushings and the metallizing of ends of Teflon tubing to provide a means of sealing.

Reduction of lead sulfide with sodium carbonate in an electric furnace has been achieved on a pilot scale at the Soviet Union's Kazakh Institute. Using a concentrate containing 50% Pb, about 70-100% by weight of soda ash (compared to total weight of concentrate) is needed to complete reduction, since silica and alumina must also be reduced. According to the percentage and quality of soda ash used, lead yield varies from 96% to 98.6% of theoretical. Most of the molybdenum, selenium and tellurium passes into the slag, nearly all the cadmium goes up in the flue dust, while gold, silver, bismuth and antimony remain in solution in the lead.

Columbium flotation process has achieved "highly satisfactory results" in a mill test on a 150-ton ore sample conducted by Columbium Mining Products, Ltd., Toronto. Using its patented flotation flowsheet, firm produced concentrates containing 45% to 48% columbium pentoxide, with overall recoveries around 85%. The starting ore, which was predominantly pyrochlore, averaged only 0.4% Cb_2O_5. Company is now designing a 250-ton/day pilot plant that will incorporate the new flotation process.

Plants

Chemoil Corp., New Orleans, plans to build an oil refinery on the Mississippi River, somewhere between that city and Baton Rouge, La. Facility is expected to cost about $60 million, will process some 40,000 bbl./day crude oil to yield LPG, gasoline, other motor fuels, and petrochemicals such as ethylene and propylene. Firm has been negotiating with an undisclosed, New York-based, major oil company that will buy most of the refinery's output of motor fuels, including gasoline. According to an unconfirmed report, the plantsite will be near Gramercy, La.

Chemoil announced plans for this refinery earlier, but at that time intended to build a facility only half as big as the one described above.

Atlantic Refining Co. and **Pure Oil Co.** have announced a joint venture to make aromatics in a 50-million-gal./yr. Udex (UOP aromatics extraction) unit that will be at Pure Oil's refinery in Nederland, Tex. The two firms will participate equally in the venture, and feedstock for the unit will come from both the Nederland refinery and one that Atlantic operates near Port Arthur, Tex. Principal product will be benzene; some toluene and xylenes will also be made. M. W. Kellogg Co., New York, will build the Udex plant, which is scheduled to be completed by December.

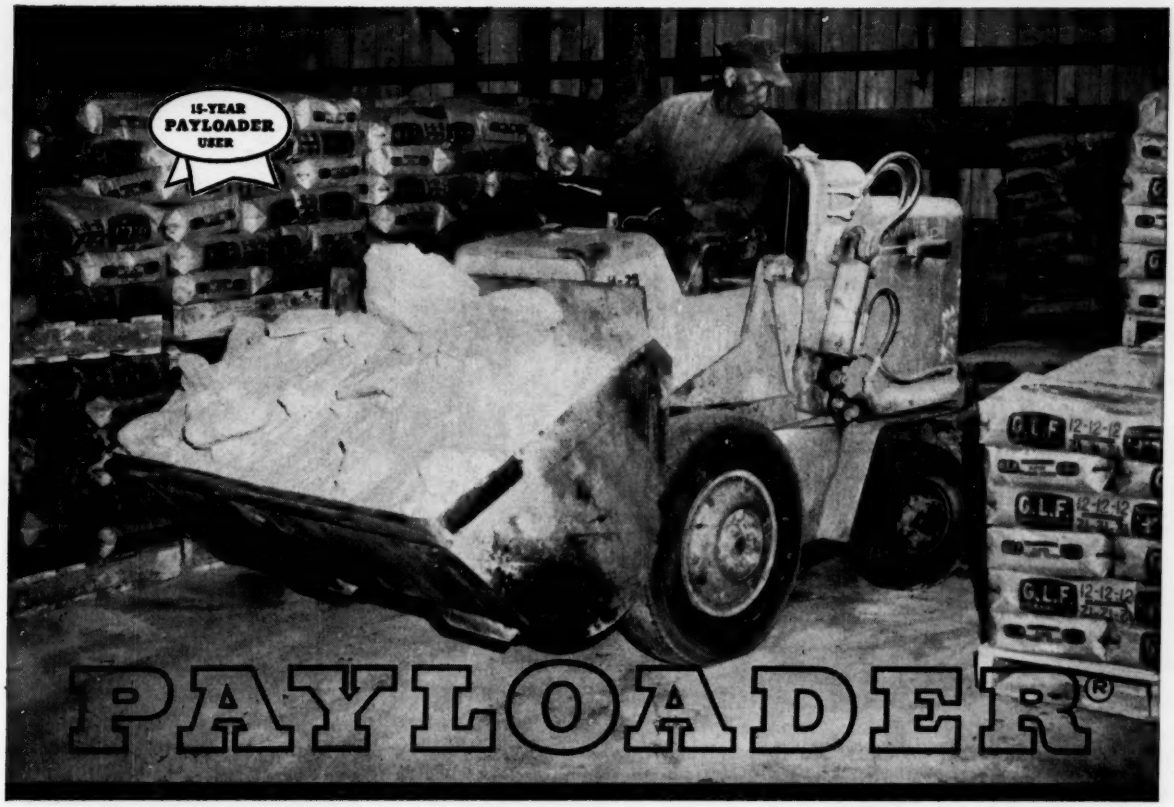
Du Pont is expanding methanol facilities at its Sabine River Works, Orange, Tex. This expansion, together with recently completed process changes at the firm's works in Belle, W. Va., will increase Du Pont methanol capacity by over 35%. Construction at Orange is expected to be completed late this year.

The company makes methanol from natural gas feed, converts a good part of the alcohol to formaldehyde, for manufacture of resins, adhesives, textile intermediates, ethylene glycol and agricultural chemicals.

Stepan Chemical Co., Northfield, Ill., is entering the field of antiknock gasoline additives. Company has a working agreement with an Italian firm, Societa Lavorazioni Organiche Inorganiche (or S.L.O.I.), under which S.L.O.I. will provide Stepan with design information and technical data for processes to manufacture tetraethyl and tetramethyl lead. The Italian company will also furnish training for Stepan operating personnel, and the Illinois firm will be permitted to use the S.L.O.I. plant at Trento, Italy, as an exact model in constructing its own plant.

Stepan has not yet announced

CPI News Briefs continued on page 150



continuous, dependable production

A 4-wheel drive PAYLOADER (Model H-70) is used by the Mills Division of G.L.F. to switch an average of 50 in and out-bound railroad cars daily on company-owned spur tracks. An average push moves 4 or 5 cars at a time. Average weight of loaded car is 95-tons.

1,500 hours and no downtime . . . that's the record of the H-25 PAYLOADER in its first year of operation in the Soil Building Division, Co-operative G.L.F. Exchange, Inc., at the Port of Albany, N. Y. This performance prompted Manager Harold Davis to say, "Our H-25 PAYLOADER proved to be a real workhorse . . . ruggedly constructed for continuous, dependable production."

G.L.F. has plenty of experience to back up this judgment. They manufacture granular fertilizer at the rate of 30,000-tons annually at this plant, and have used PAYLOADER tractor-shovels for 15 years to unload rail-cars, convey materials to the mixing operation, charge bagging machines and for bulk loading at their many plants.

In logging 1,500 hours, they estimate this PAYLOADER handled 30,000 tons of fertilizer on a maximum 200-foot delivery cycle: Conveying materials to storage, it averaged 20 tons per hour; in moving material from the bins to the packer it averaged 15-20 ton per hour.

Production Protection . . . many special features are "built-into" the H-25 PAYLOADER to protect its mechanical and electric parts against downtime due to damage from dust, moisture and corrosion. Also, it is the only loader in the 2,500-lb. operating capacity class with a *complete* power-shift transmission (2 forward and 2 reverse speeds). Power-steering, power transfer differential and wet-sleeve overhead valve engine are standard. Call your nearby Hough Distributor for complete data and a demonstration on the H-25 or, return the coupon.

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BRIGHT FUTURE FOR STARCH CARBOHYDRATES

Vast markets in food, paper and textiles attract the amylose and amylopectin fractions that are now commercially separated from dent corn.

Recent introduction by the A. E. Staley Mfg. Co. of amylose and amylopectin has culminated nearly 60 yr. of efforts to extract and separate reasonably pure fractions of these materials from cornstarch.

Stating only that the process does not rely on genetics to alter grain composition and thus favor fractionation of the isomers, Staley claims that the products, derived from dent corn, are priced competitively. According to the firm, a relatively pure potato starch amylose produced by a Dutch process (*Chem. Eng.*, Mar. 24, 1958, p.68) costs considerably more.

Reason why amylose and amylopectin have evoked so much research effort is that they contain the same glucopyranose units also found in cellulose. But unlike cellulose, these new fractions enter fully into the human metabolic process because of structural differences in their orientation of the OH groups and glucosidic linkages.

They are found mostly in starches from potatoes, waxy maize or waxy sorghum, and corn. The starch refined from dent corn is about three fourths amylopectin and one fourth amylose. Unfortunately, when combined in this ratio, both carbohydrates lose many of the desirable chemical and physical properties that they would possess if fully separated. Pure amylose, for instance, can be used in making high-strength paper coatings, packaging films for various foods, and can be spun into filaments for textiles. And pure amylopectin thickens or suspends foods like soup and pie fillings, and is also used in texitle sizing.

Dr. E. E. Fisher, of Staley Mfg. Co., shows molecular model of amylose.

▶ **Food Applications**—Considering the accomplishments of cellulose (in plastics, lacquers, rayon, cellophane, explosives, cigarette filters, tire cord, photographic films), the potential of amylose and amlopectin looms even larger on the horizon because of the great number of possibilities they also offer in the food industry.

Amylopectin's immediate potential is apparent in the market for modified amylopectin starches derived from waxy maize. This market has grown from nothing to more than 120 million lb./yr. consumption in foods over the last 13 yr. But unlike the waxy-maize derivative, amlopectin derived from dent corn can easily be made soluble in cold water—an important advantage for food processors.

Applications for the pure amylose fraction that now becomes available are also interesting. Wrapped in edible amylose films, frozen vegetables, meats and sausages can be placed in a pan of water and cooked, transparent wrapping and all.

▶ **Paper and Textiles**—One of the early laboratory methods for separation of amylose from amylopectin in solution was based on the selective absorption of amylose by cellulose fibers, a crude but convincing demonstration of the carbohydrate's stronger binding nature.

The paper industry with its demand for huge quantities of cornstarch in coatings, sizings, pigment binders and adhesives, will probably be one of the largest users of the new isomers.

Experimental amylose-clay paper coatings have shown substantially increased adhesive strength and pick resistance. Other advantages of this starch fraction in paper include wet strength, water and grease resistance.

Also, amylopectin is credited with distinct advantages in a number of adhesives, notably among them the gummy adhesive used on the back of U.S. postage stamps, an outlet of several million pounds a year.

Because the amylose fraction forms good films that are flexible and insoluble, it appears adaptable to permanent fabric finishes for crease resistance, sheen and durability. In nonwoven fabrics, amylose-rich intermixes serve as a solution-type binder, opening the way to cotton-starch combinations, long regarded as a vast market for both crops, in disposable fabrics, cloths, napkins and garments.

And in warp sizing, the new products increase loom speeds and overcome sizing problems common to synthetic blends and yarns.

In studies of fiber properties, fine filaments were drawn and spun from amylose triacetate in the size range needed for textile applications. Although the undrawn filaments had lower tensile strengths than comparable ones of cellulose acetate, they gained

Quality control is a relentless task at J&L. Here a skilled metallographer examines steel structure through a modern photomicroscope.

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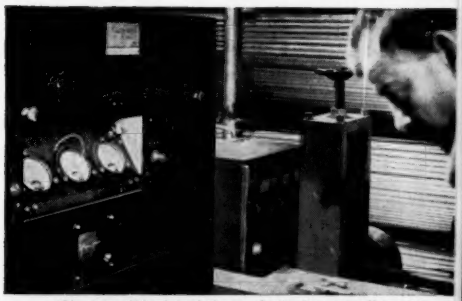
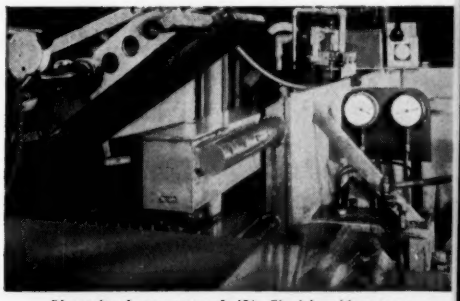
J&L Electricweld pressure tubing is the finest carbon steel tubing available for heat exchanger, condenser, boiler, evaporator and other applications—yet shows savings of as much as 45% against seamless tubing.

J&L Electricweld pressure tubing provides the uniform outside diameter, wall thickness and concentricity that guarantee excellent heat transfer characteristics and fine surface quality. Its strength and ductility assure easy fabrication and installation.

J&L Electricweld pressure tubing is subjected to precise checks at every stage of production, from the basic steelmaking process until the tube is ready for shipment. This series of critical examinations on every length of tubing—inside and out—assure you of perfect field performance. Further details of Electricweld tubing and the economies it offers compared with seamless are available on request from J&L—creator and producer of *unmatched* Electricweld tubing.



J&L uses this latest type of electro-magnetic non-destructive tester to inspect both the inside and outside of Electricweld pressure tubing.



Dimensional accuracy of J&L Electricweld pressure tubing is determined long before fabrication. Shown here is an X-ray gauge control device which continuously measures the gauge of the sheet and strip steel.

This Steelmark identifies products made of steel. Place this mark on your products. And—look for it when you buy.

Steel

J&L STEEL

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strength because the drawing oriented the molecules, showed much greater elongation at break.

In summation dent-corn amylose and amylopectin, obtained until now from costly laboratory separations, present great opportunities in paper, textile and food applications.—**A. E. Staley Mfg. Co., Decatur, Ill.** 80A

Lactic acid

Rich in dextrorotatory isomer, lactic acid solutions improve foods and plastics.

Lactic acid solutions in which the dextrorotatory isomer predominates (> 82% content) are now available in pilot-size lots.

Until recently, commercial quantities of lactic acid have consisted of a racemic (optically inactive) mixture of dextro- and levorotatory isomers.

The preponderance of dextro isomer (the form commonly occurring in man and animals) is expected to replace the racemic mixture used in foods, drugs and resins.

This new lactic acid solution minimizes undesirable flavors in fermented foods and beverages produced by lactic bacterial fermentation, and improves the efficiency of protein utilization in feeds, egg production and poultry growth. In the synthesis of polyester resins, these lactic solutions are reported to favorably affect the tack point of isotactic polymers.—**Miles Chemical Co., Elkhart, Ind.** 82A

Polyethylene

Plastic now bids for intercontinental cables, keeps expanding in packaging films.

Two new grades of polyethylene, each aimed at different markets, will soon be available. One, made by Carbide, is an electrical insulator (with a high resistance to stress cracking) that will go into transoceanic telephone cable systems. The other, produced by Eastman, is a low-melt compound designed for extruding the clear and tough films needed in packaging operations.

▶**No Impurities**—Carbide's product, called Bakelite DFDA-0173, is an unmodified, high-molecular-weight polyethylene that contains only antioxidant. Its high resistance to stress cracking comes from "technological developments" (Carbide is silent on details) and not from the butyl rubber that usually boosts this property in similar products.

Exclusion of butyl rubber, a major source of contaminants, has given a compound of exceptional purity, which won't break down or fail in high-voltage applications.

Composition and electrical characteristics of this polythylene are controlled within narrow limits because variations in the dissipation factor, dielectric constant and even the thickness of the insulation, can greatly reduce the cable's efficiency. Although Bakelite DFDA has a low melt index, it can be extruded with a minimum of surging and thickness variation, thus avoiding capacitance fluctuations and other distortions in the electrical circuits. And its stress-cracking resistance forestalls cable failures and the resulting expense of locating and repairing the damage.—**Union Carbide Plastics Co., New York.** 82B

▶**Clear and Tough**—Films extruded from Tenite 161M (a low-density polyethylene formulation) have high impact strength at low-temperatures, are optically clear, and have been found superior in their slip and antiblocking features for high-speed packaging operations.

Tenite has a medium slip-agent level and extrudes well either by flat-film or blown-film methods of extrusion.

Because of their great tear strength, these films are recommended for packaging frozen foods, particularly those that are individually quick frozen, and are well suited for other packaging applications in which toughness and clarity are required.

	Bakelite DFDA	Tenite 161M
Density	0.923	0.923
Tensile strength, psi.	2,400	2,200
Yield strength, psi.	1,600	1,700
Elongation, %	600	600
Brittle temp., C.	<-45	<-75
Melt index, C./min.	<0.1	0.6–0.8
Dissipation factor (23 C., 10^3 to 10^6 cycles)	0.00012	.....
Dielectric constant (23 C., 10^3 to 10^6 cycles)	2.283	.....

Eastman Chemical Products Inc., New York. 82C

Briefs

Diethylene glycol, offered in a new grade, features narrower distilla-

Newsworthy Chemicals

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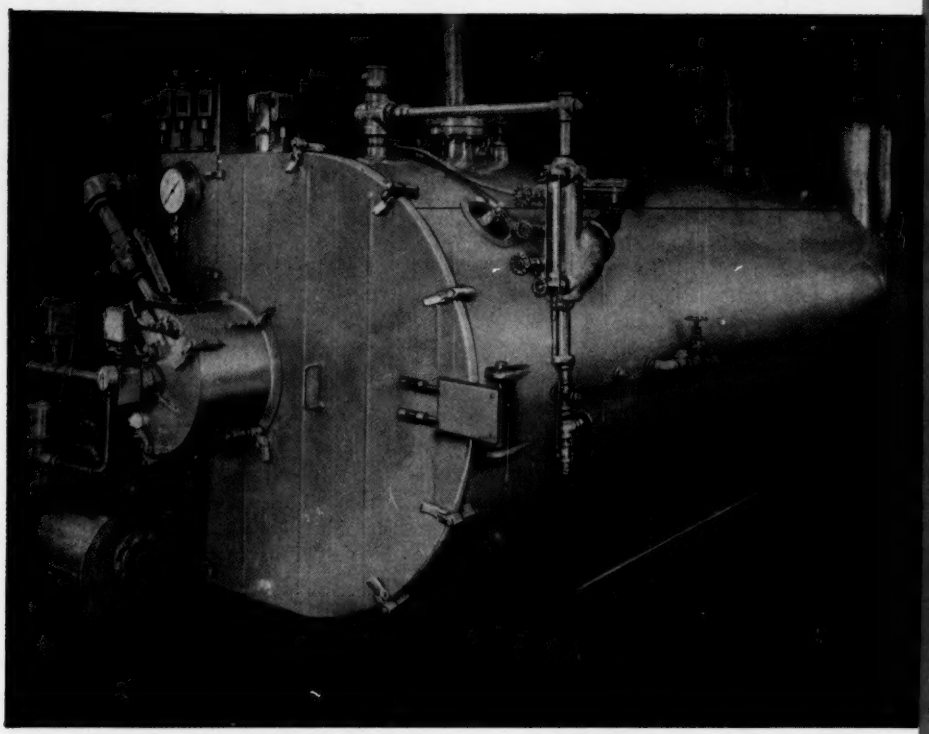

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The result of more than two years of development and testing, the *Powermaster Positive Flow* boiler has been tried, tested and proved by one of America's foremost consulting engineer firms. Among its many tried and proven features are: accelerated internal circulation which greatly improves heat absorption efficiency . . . *PyroFlow*® burner system which can be easily converted in the field from/to either oil or gas without burner modification . . . hinged front and rear covers . . . optional dryback or wetback construction . . . quieter operation.

No other boiler can match the performance of the Powermaster Model PF for generating steam or hot water economically and dependably. A comparison of performance tests with other boilers will prove this is no idle statement.

For complete details of the *Powermaster Positive Flow* boiler, write for Bulletin No. 1275. If you are interested in leasing the boiler, a leasing arrangement may be made with your local O&S distributor.

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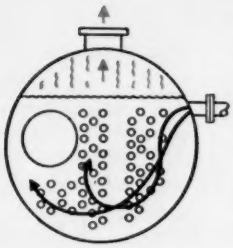
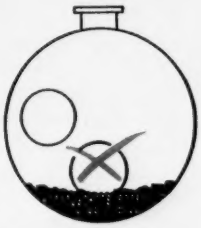
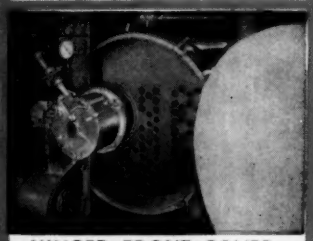


POSITIVE CIRCULATION
Design permits boiler feed injection and natural thermal circulation to augment each other. This provides the maximum water circulating rate and the most efficient form of heat transfer, **counterflow.**



SIDE LOCATED FURNACE
Side located furnace eliminates danger of heat damage due to stagnant water and sludge. Turn-around spaces are simple, accessible and positive sealed.



HINGED FRONT COVER
Hinged front cover, with quick-opening fasteners (no bolts) can be opened for access to heating surface without disturbing burner, wiring or piping.

DIVIDED REAR COVER
Hinged rear cover, also with quick-opening fasteners, permits ease of accessibility and maintenance. Each cover section forms a separate seal in a single plane, providing protection from short-circuiting of combustion gases. No internal baffles to leak.

tion range, more precise water-content control and reduced acidity. Improved grade makes for more uniform product quality and process control in detergents, textiles, adhesives and natural gas dehydration.—**Union Carbide Chemicals Co., New York.** 82D

Cesium metal 99% pure, currently used in minute quantities in TV cameras and electron-multiplier photoelectric cells, expects to find a large market in thermonuclear converters based on plasmas and as a propellant in ion propulsion motors for space ships, because of its ability to ionize easily. Now available in commercial quantities, Cesium is also a grain refining agent for aluminum and a heat transfer medium in power generators. — **U. S. Industrial Chemicals Co., New York.** 84A

New iron alloy for roller bearing retainers has a coefficient of expansion close to steel's, and a permanent expansion lower than that of bronze. (Bronze is the conventional roller-bearing retainer material.) Also lighter than bronze but with a higher yield strength, this iron alloy, known as Rollube, operates satisfactorily at temperatures up to 800 F. in boundary lubrication.—**Rollway Bearing Co., Syracuse, N. Y.** 84B

Acrylonitrile-based cement, H-523 Ubabond, for joining vinyls, develops high initial bond strength that markedly increases upon aging. Tackfree when dry, adhesive joins not only vinyls but also ceramics, steel, tinplate, leather, other materials.—**UBS Chemical Co., Cambridge, Mass.** 84C

Aluminum-brazing wire, designed for nuclear and radiochemical fabrication markets, has been granted Nuclear Grade certification. Three aluminum alloys are involved, all of which contain bare minimum levels of unwanted Li, Cd, B and Co.—**All-State Welding Alloys Co., White Plains, N. Y.** 84D

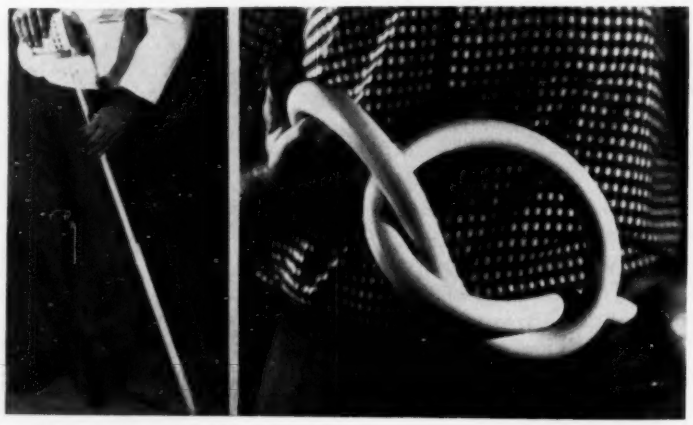
Di-tertiary butyl peroxide, reported as an excellent polymerization catalyst (at 212 F. or over) in the production of polyacrylates, ABS resins and vinyl silicones, is commercially available at 97% purity. Stable and unaffected by solvents, product contains minimum of hydroperoxide impurities. —**U. S. Peroxygen Corp., Richmond, Calif.** 84E

Plastisol stabilizers Ferro 1776 and 1777, functioning by synergistic action of metallic and nonmetallic components, are light amber liquids that give heat stability and color retention without sulfur staining. Ferro 1776 goes into unfilled clear plastisols and 1777 is used in filled plastisols.—**Ferro Corp., Cleveland, Ohio.** 84F

Propargyl alcohol, now commercially available as a 75% solution, is used with hydrochloric and sulfuric acid to prevent hydrogen embrittlement, inhibit corrosion during pickling, and in the descaling of iron with HCl. It can also acidulate oil wells.—**Antara Chemicals, Div. of Gen. Aniline, New York.** 84G

1-naphthyl methylcarbamate, a free-flowing insecticide, disperses quickly in all sorts of spray machinery, including the low-agitation types found in airplanes. Compound boasts high toxicity on insects, worms and moths; yet low toxicity for warmblooded animals, birds and fish.—**Stauffer Chemical Co., New York.** 84H

Fluid silicone rubber solidifies quickly at 77 F.

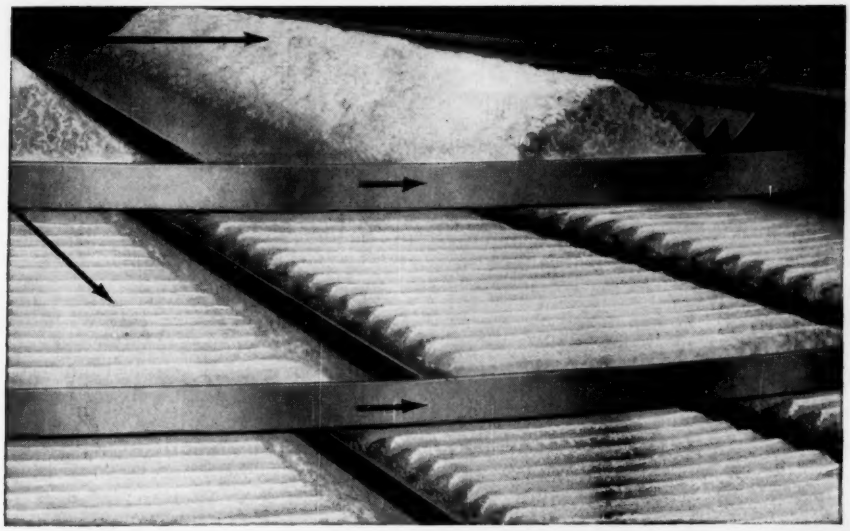


Catalyzed silicone rubber poured into the glass tube (left) was left standing for 24 hr. at room temperature. After breaking the glass, the fully vulcanized, flexible silicone was removed (right)

This fluid compound, identified as Silastic RTV 601, can also vulcanize in solid sections of any thickness—as quickly as the thin rod shown—without even need for venting, because no volatile byproducts are formed during vulcanization.

Silastic's aplications range from the making of flexible molds and castings of prototype parts, to potting and encapsulating deep or totally enclosed electronic components. Parts or sections made of this silicone rubber can immediately be put into full service at temperatures from —100 to 500 F.—**Dow Corning Corp., Midland, Mich.** 84I

For More Information about any item in this department, circle its code number on the Reader Service Postcard (Page 181)



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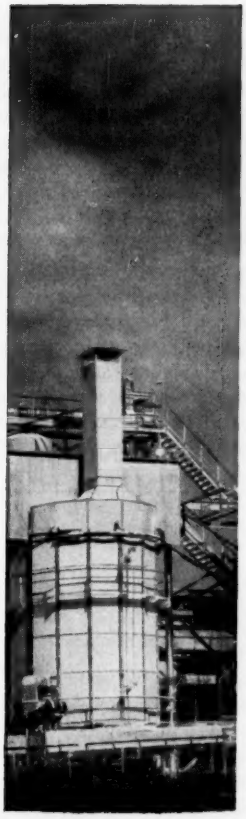

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Connected to a gas source, generators can produce 5, 10, 50 or 100 w.

TURN ON GAS–GET ELECTRICITY

Now ready for market, thermoelectric generators can supply power from gas heat for remote operations.

No plant can generate its own electricity directly from heat, but more devices are coming on the market that utilize the thermoelectric principle.

Latest generator, developed by Westinghouse and now commercially available, is ideally suited for applications in remote areas where electricity is nonexistent, but gasoline, natural gas or propane can be supplied. Designed to produce 5-5,000 w., the unit will probably see initial service for cathodic protection of pipelines, for valve control, and for powering microwave relay equipment.

▶ **Operating Temperatures**—Depending on applications and type of fuel used, the generators operate at core temperatures between 570 and 1,120 F. Typical propane-burning units operate at 750 F.

Thermoelectricity depends on the temperature difference between two dissimilar materials formed in a junction. Power output is greatest at a particular optimum temperature, although operation at this temperature magnifies problems of corrosion, oxidation and deterioration.

Westinghouse has incorporated some recent improvements in thermoelectric materials into the new devices. In addition, techniques were used that permit the construction of more-oxidation-resistant thermoelectric couples. All electrical contacts between pellets are either soldered or brazed; the units are free from pressure-bonded contacts that are subject to oxidation and deterioration.

▶ **Outdoes Magnesium** — One obvious market for the devices: cathodic protection of pipelines. Present method of protection may involve magnesium bars buried in the ground near the pipeline. Magnesium's shortcomings: bars are eaten away in the protection process, have to be replaced periodically. Especially in highly corrosive areas, thermo-electric generators promise possible longer life and less attention than magnesium. And the devices can be fueled by taking gas directly from the pipes they protect, which enhances their value in remote locations.

▶ **Recover Waste Heat**—Northern Illinois Gas Co., purchaser of a 100-w. generator (largest size pictured) plans not only to expand its cathodic protection experimental work, which has been under way for some time, but also will experiment with furnaces in an effort to show that waste heat now lost up the chimney can be economically recovered via a thermoelectric device. Power thus generated would be used to operate the furnace blower and control system, freeing the entire unit from dependence on outside power.

The new generators basically have low-voltage, high-current d.c. outputs, but a variety of static inverters or converters can be supplied to provide a desired a.c. or d.c. output rating.—**Westinghouse Electric Corp., Pittsburgh.** 86A

Discharge vent

Horizontal opening blows out ignited vapor, prevents fire.

Under normal (i.e., nofire) conditions, this weatherhood vent protects storage-tank contents from rain, airborne contaminants, etc.; yet at the same time permits effective vapor exhaust. If vapor

suddenly ignites, however, a heat-sensitive alloy fuses, and the vent unit drops free. Discharge immediately becomes horizontal, preventing dangerous impingement of fire on the tank proper.

Hood itself, which directs the exhausting vapor at a slight downward angle from the horizontal under normal use, is made of aluminum. A chain connects it to the valve body, so unit is not lost in the event of fire.—**The Protecto-seal Co., Chicago.** **86B**

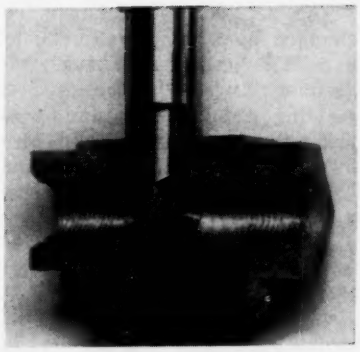
Polyethylene tank

Huge container holds 350 gal., when filled is self-supporting.

Designed for storage or mixing operations where noncontamination is essential, this 350-gal. molded-polyethylene tank has wall thickness of only ⅛-in.—yet is nondistorting, self-supporting even when filled.

Advantages claimed for the translucent, colorless tanks include easy cleaning, light weight, long life, and complete resistance to concentrated acids. Successful tests have been run on a rare-earth extraction process involving concentrated HCl and acetone solutions.

Unit is two-piece: 46 × 52-in. molded-polyethylene container, and fabricated-polyethylene cover. —**American Agile Corp., Bedford, Ohio.** **87A**



Solenoid valve

Lightweight unit has no organic parts, promises versatile service.

A new solenoid-operated shut-off valve has no washers, gaskets, packing or O-rings, hence may be used over a broad range of temperatures and pressures with a wide variety of fluids that might react with organic internals.

Constructed entirely of stainless steel and aluminum, valve's sealing-disk design permits straight-through flow with low pressure drop. Port sizes range from ⅛-½-in.; valve works well on small lines because turbulence and pressure drop are minimized.

This all-metal unit has only two moving parts—the plunger and sealing disk. No seal is necessary since plunger is actuated from outside of housing. Designed for low-friction operation, the valve has low power requirements (a.c. or d.c.), is said to be suitable for applications where inaccessible location requires long life without maintenance.

Present models will withstand up to 5,000 psi. An all-stainless steel unit under development works at higher pressures and temperatures. — **Polymet Co., Orange, N. J.** **87B**

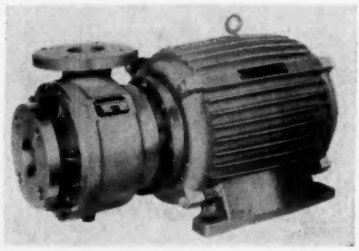
Punched-tape reader

Computer accessory reads tapes photoelectrically.

Designed to read 350 characters/sec. from 5-, 7- or 8-level punched-paper tape, photoelectric reader is built of solid-state components throughout. It is available either with or without reading circuitry.

Unique reading head with special windows channel a beam of light through the tape's holes to the photocells. Placement of windows results in smooth reading surface, and is said to eliminate danger of accumulated dirt plugging up holes. Various colored tapes, as well as oiled or soiled tapes, are read without adjustment of bias voltages or amplifiers.

Unit will read either a character at a time, or continuously to stop-code point. Weighing 34 lb., and standing 9 × 11½ × 10 in., unit is now in production. Small orders are being filled from inventory.—**Control Data Corp., Minneapolis, Minn.** **87C**



Sealless pump

Pumped fluid does all cooling and lubrication in canned unit.

Operating without seals, a new canned pump is lubricated and cooled by the fluid it is pumping. According to the manufacturer, pump design provides the lowest weight/size vs. performance ratio of any pump available. The 15-hp. unit, designated Model 6222P-15S, develops 200-ft. head at a flow rate of 230 gpm.

Pump's welded stainless steel-clad rotor and stator allow the pumped fluid to pass through the motor air gap. Motor is protected from overheating with a thermal overload switch. Pump castings are available in either passivated 300 series stainless steel or 356-T6 aluminum alloy.—**J. C. Carter Co., Costa Mesa, Calif.** **87D**

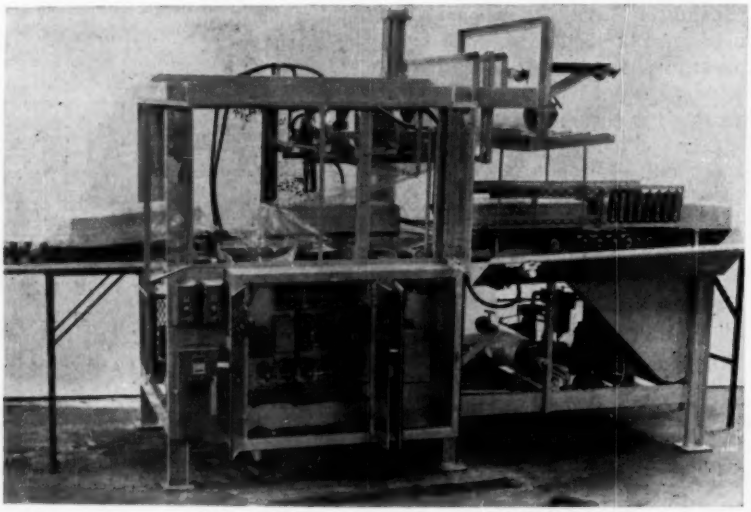
Solids classifier

Cut point is adjustable for different sizes of dry powders.

Solids classification for pilot-plant studies, research and development operations and small production is aptly handled with a versatile unit that separates up to 250 lb./hr. of fine dry powder into preset size classifications. It has demonstrated its efficiency in handling such materials as powdered metals, fine abrasives, solid fuel components, resins, polymers and rare earths.

The separation point can be changed by a simple adjustment of a calibrated shutter ring. Adjustment is said to be precise, yielding reproducible and consistent results. Rotor speed is also adjustable, to assure that feed and air velocity are matched. Supplied as a package that includes classifier, exhauster, fine and coarse powder collecting systems, motor and controls, the unit is portable.

In operation, feed falls on a rotating distributor that accelerates and deflects the powder downward into the classification zone, where an air vortex carries the fine particles inward and down, away from the coarse particles, which are carried by centrifugal force to impinge on the outer wall and thence be separately collected. Vortex angle and rotor adjustments set the selected cut point. **—The Sharples Corp., Bridgeport, Pa.** 88A



Rubber-bale wrapper

Tacky synthetics are surrounded by a sealed plastic envelope.

Synthetic rubber, or any similar material that has high flow properties or is tacky, can be automatically packaged for shipment with a new machine that positions, wraps and seals bales at up to 8/min.

New wrapping unit overcomes obstacles that plagued bale handling previously, such as cold flow, film breakage, bale-to-bale adhesion and/or sticking of the rubbers to the unit container or bag. Various styrene-butadiene-type rubber as well as other rubber types have been satisfactorily packaged with the baler by several companies.

In operation, the machine accepts rubber bales from a conveyor, positions them between top and bottom sheets of clear or opaque plastic film, and heat-seals the openings electrically to form a protective envelope having sufficient space on all sides for in-transit plastic movement of the rubber, without breaking the enclosing film.

Plastic wrappings may be polyethylene, biaxially oriented polystyrene or a polyethylene-polyisobutylene blend. Output can exceed 100,000,000 lb./yr. per machine, according to the manufacturer.—**Texas-U. S. Chemical Co., Port Neches, Tex.** 88B

Controllers

Line of round-chart instruments control most process variables.

Temperature, pH, speed and other variables are recorded on circular graphs and controlled by this line of electric-signal instruments.

Self-contained and null-balancing, controller are based on transducer mechanisms. Only an external sensing device is required to complete the system. Any quantity that can be resolved into electrical signals can be recorded and controlled. Operational servicing, chart replacement and range ad-

More New Equipment continued on page 164

For More Information about any item in this department, circle its code number on the Reader Service Postcard (Page 181)

NEW C-200 HEAT EXCHANGER FOR INDUSTRIAL OR PROCESS HEATING OR COOLING

C-200 exchanger is a high-quality unit, assembled to your order from pre-engineered and fully standardized components. Moderate in initial and operating costs. Specifically designed and built for long service in chemical and process industries. Type C-200 handles any combination of liquids or gases. Can be used as heater, cooler, condenser or vaporizer. Tubeside available in stainless or carbon steel, cast iron. Tubesheets also available in rolled brass clad steel. Triangular pitched straight tubes of any tube material. Code constructed expansion joints when required. Get the full story. Request Bulletin 301.7K1. American-Standard Industrial Division, Detroit 32, Mich. In Canada: American-Standard Products (Canada) Limited, Toronto, Ontario.

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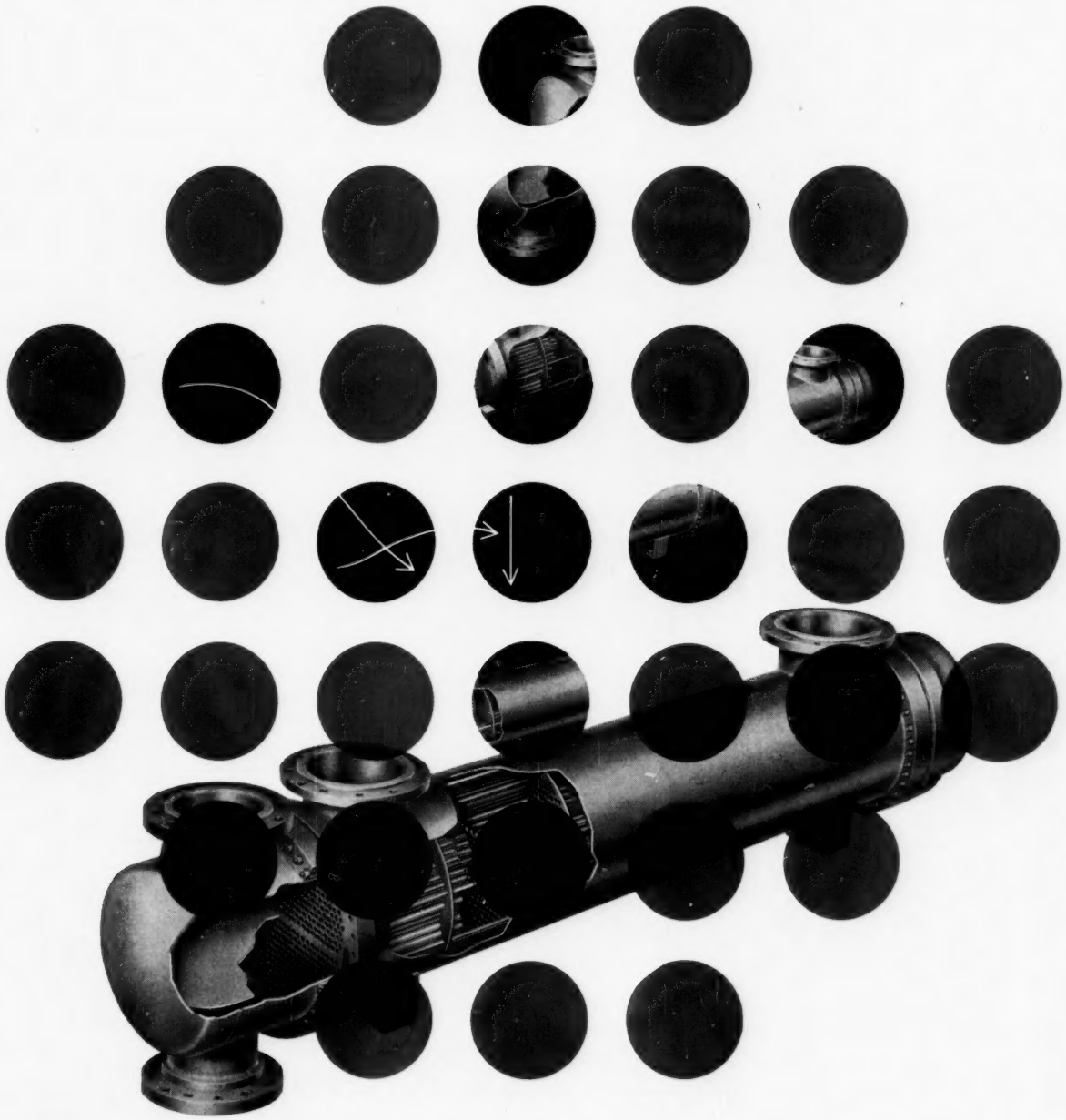


Process Flowsheet

Process Maze Yields Maize Products

English plant features both modernness and diversity as it turns out a broad line of industrial products from raw-material corn.

T. P. FORBATH
*McGraw-Hill World News: Bonn, Germany**

It's a far cry from hot, buttered corn on the cob to such industrial products as starch ethers and British gums. But this spread gives an idea of the broad slate of end uses to which a very down-to-earth raw material—ordinary corn—can be processed.

As might be expected, manufacturing plants in the corn products industry differ greatly in scope of their operation. Some turn out only a few of corn's many possible end products; others operate on a more diversified scale.

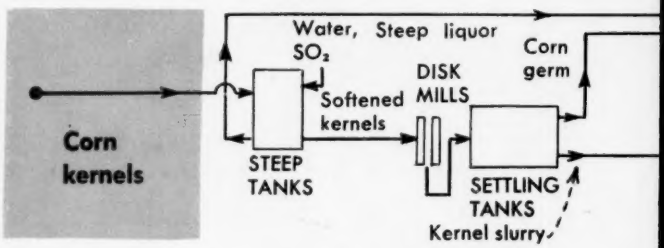
A good example of the latter type is the Manchester, England, plant of Brown & Polson, Ltd., subsidiary of Corn Products Co., New York. On stream with its present scope of operations since '58, this modern facility turns out a long list of industrial products from corn, using up-to-date techniques that typify latest U. S. practice.

▶**What It Makes**—Plant capacity is a guarded secret—B & P says only that the facility is the largest of its type in Europe. Although its scope isn't as great as that of, for instance, Corn Products' huge works at Argo, Ill. (which turns out food products as well as industrial materials), the Manchester plant's diversity can be readily seen from a look at its product slate.

Included are ordinary, pure starch; pregelatinized starch; other specialty starch products such as oxidized and thin-boiling starches and starch ethers; dextrines and British gums; corn oil; gluten meal and feed; dextrose; solid sugars; liquid glucose; and corn-steep liquor. Company considers all its products as equally significant, alters scheduling and product output in accordance with variations in market demand.

Raw-material shelled corn ("maize" on B & P's side of the Atlantic) comes mainly from the U. S.; some is also imported from South America and South Africa.

▶**Tracing the Maize**—Processing starts in a countercurrent system of tile-lined steep-tanks. The maize is softened by steeping at 124 F. for 40 hr., in a solution of 0.1-0.2% sulfurous acid. Spent steep-liquor is concentrated in evaporators, then is ready for sale as animal feed supplement.



Unfold flowsheet

The softened kernels consist of germ, fiber, gluten and starch. The next processing phase separates the kernels into these four components, each of which is then processed further.

The oil-containing germ material is separated first, in a two-stage arrangement of disk mills and settling tanks. Germ is freed by the milling, floats to the tops of the tanks and is sent to oil recovery.

Germ-free kernels are ground, then washed in revolving reels fitted with nylon cloth screens. Fiber is retained on the screens while starch and gluten pass through. Latter mixture is separated in high-speed disk centrifuges followed by a bank of nine hydrocyclones.

Starch slurry from the hydrocyclones contains 99.9+% starch on a dry basis. This stream can be processed in any of several ways, depending on the end product desired.

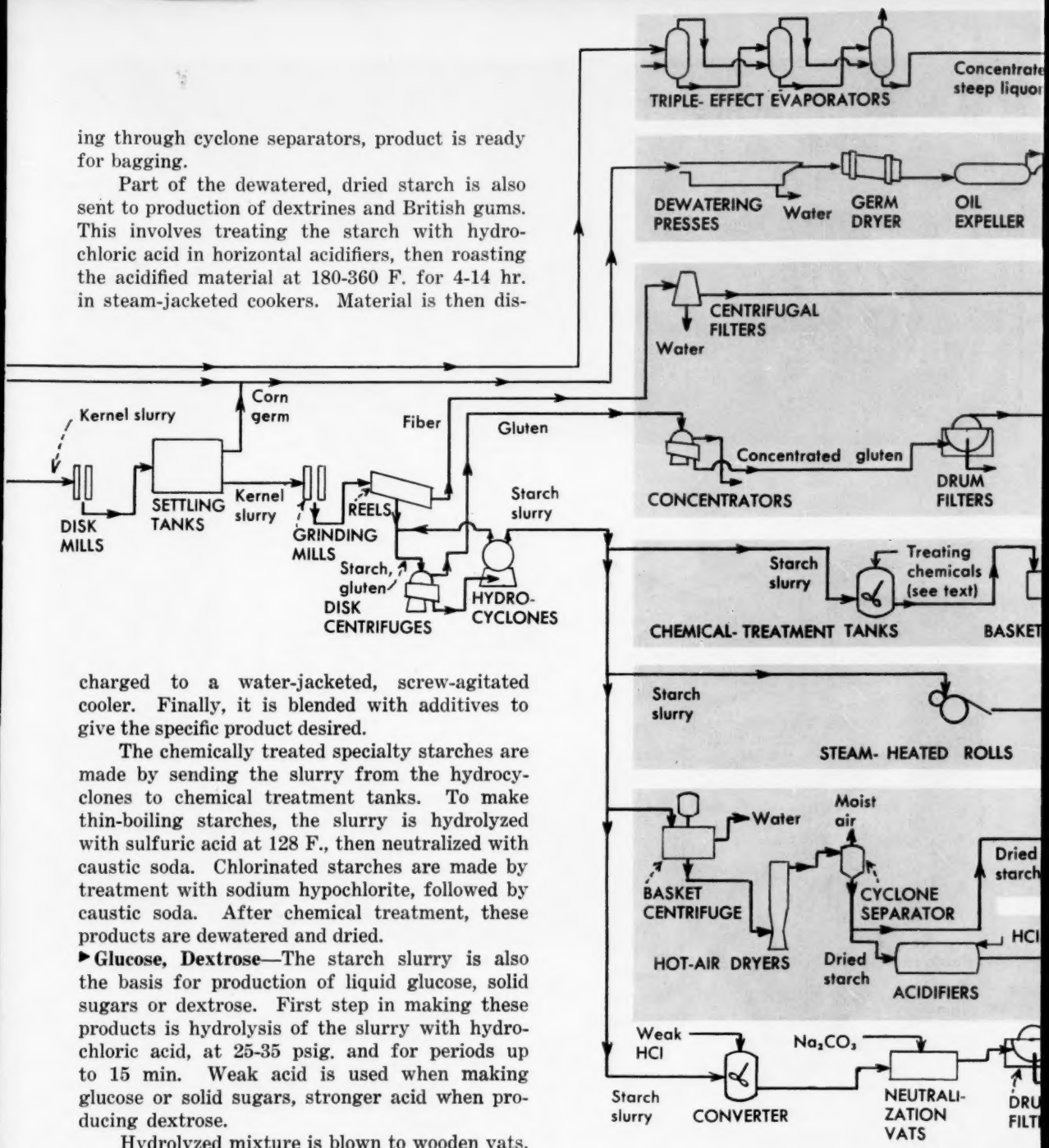
▶**Starches**—One of these products is pregelatinized starch. It is made by feeding the slurry onto the surfaces of rotating, steam-heated drums. The cooked, dried product is removed by doctor blades, then milled and screened for packaging.

Pure starch is made by dewatering and drying the slurry in centrifuges followed by a hot-air dryer containing 60-ft. vertical tubes. After pass-

*Pete Forbath, a former *CE* editor and currently the head of McGraw-Hill's news bureau in Bonn, gathered the material for this article while working with our London bureau last fall.—ED.

ing through cyclone separators, product is ready for bagging.

Part of the dewatered, dried starch is also sent to production of dextrines and British gums. This involves treating the starch with hydrochloric acid in horizontal acidifiers, then roasting the acidified material at 180-360 F. for 4-14 hr. in steam-jacketed cookers. Material is then dis-



charged to a water-jacketed, screw-agitated cooler. Finally, it is blended with additives to give the specific product desired.

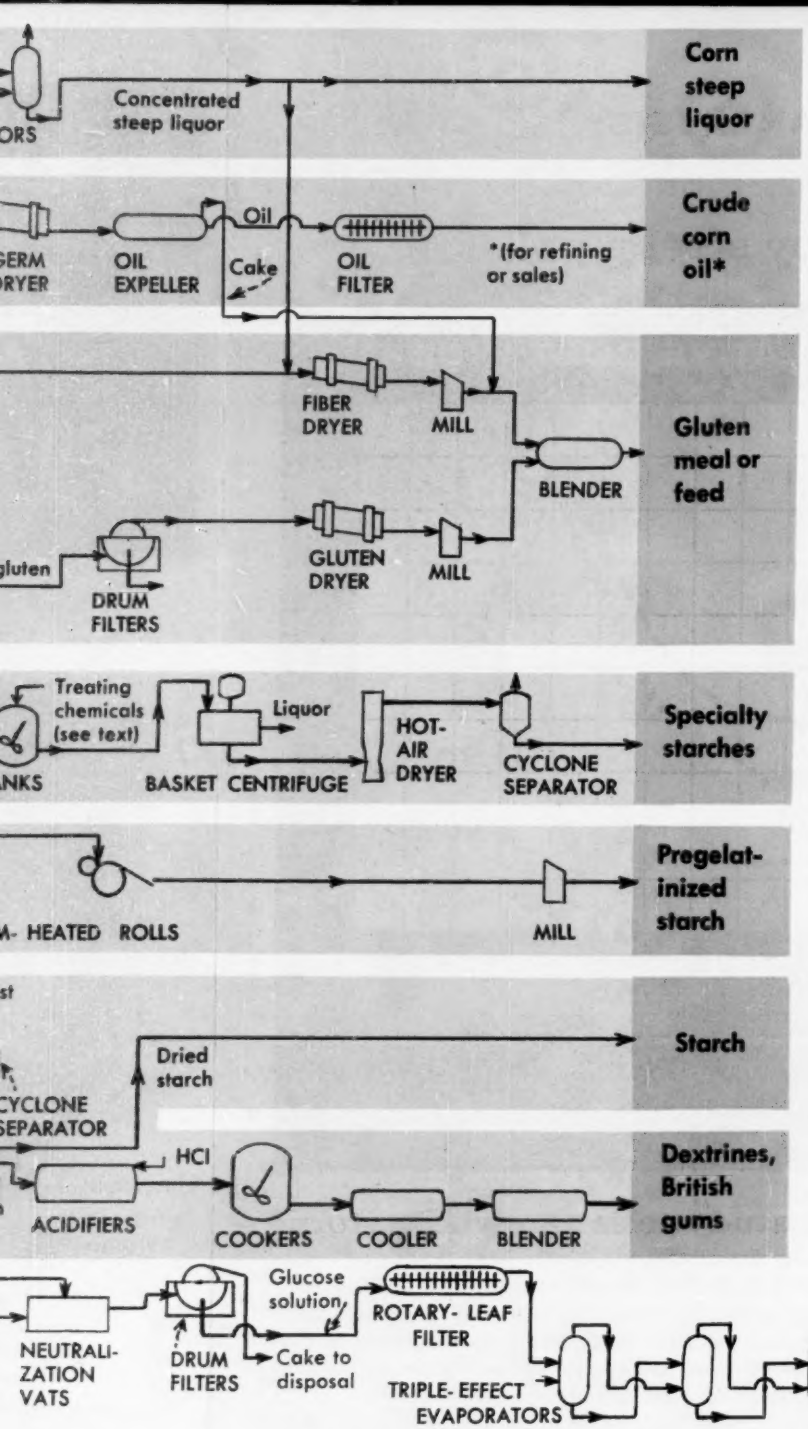
The chemically treated specialty starches are made by sending the slurry from the hydrocyclones to chemical treatment tanks. To make thin-boiling starches, the slurry is hydrolyzed with sulfuric acid at 128 F., then neutralized with caustic soda. Chlorinated starches are made by treatment with sodium hypochlorite, followed by caustic soda. After chemical treatment, these products are dewatered and dried.

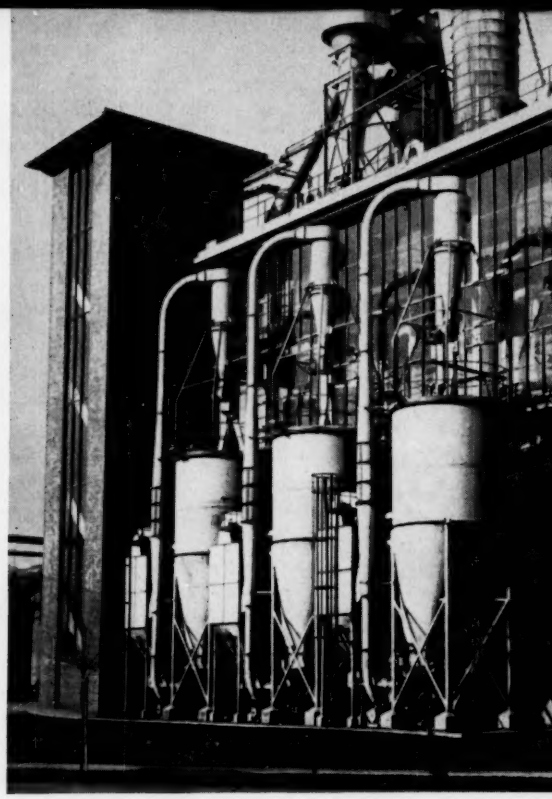
▶ **Glucose, Dextrose**—The starch slurry is also the basis for production of liquid glucose, solid sugars or dextrose. First step in making these products is hydrolysis of the slurry with hydrochloric acid, at 25-35 psig. and for periods up to 15 min. Weak acid is used when making glucose or solid sugars, stronger acid when producing dextrose.

Hydrolyzed mixture is blown to wooden vats, where it is neutralized with sodium carbonate. Mixture is then filtered on precoat drum filters.

At this point, B & P uses a cyclic arrangement of two sets of rotary-leaf filters, together with evaporators and a mix tank, to concentrate and decolorize the glucose or dextrose solution from the precoat filters. Solution passes first through one set of the leaf filters, which contains leaves coated with activated carbon from the previous cycle. Next it is concentrated in the evaporators and mixed with carbon, then finally passes through the second, clean, filter and thereby coats its leaves. In the meantime, the first filter is cleaned, and the two are used in reverse sequence for the next batch.

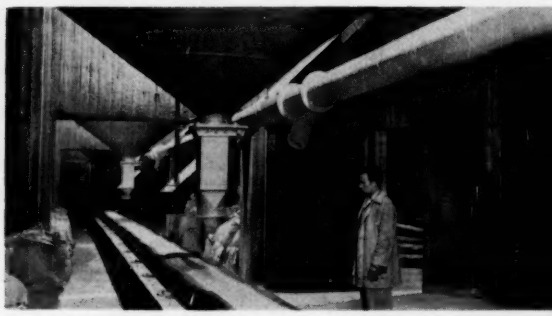
Liquid glucose can be concentrated for direct sales. To make solid sugars, the glucose is cooled in tanks, then cast in open flat trays. Dextrose solution, on the other hand, is kept for a period of about five days in horizontal, screw-agitated





Dextrine building (exterior above, interior at right) ho cookers, coolers and blenders, which are used successiv starch to dextrines and British gums. Vessels at right a

Storage bins of prestressed concrete hold raw-material



clean, filter and meantime, the o are used in h.

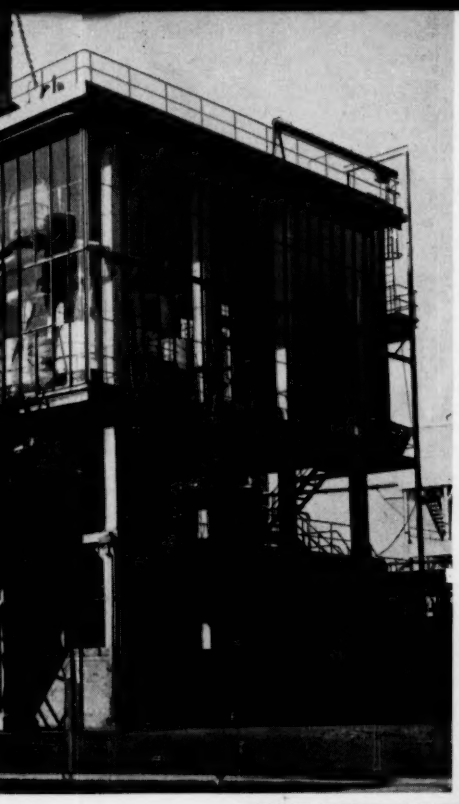
rated for direct lucose is cooled ays. Dextrose pt for a period screw-agitated

crystallizers, and the crystals are separated from the mother liquor and dried.

▶**Other Products**—The oil-bearing germ originally separated from the kernels is washed to remove adhering starch particles. Next it is dewatered by mechanical pressing, and dried in steam-heated dryers to a moisture content of 2% or lower.

Oil is squeezed from the dried germ by heated oil-expellers, is filtered and is then ready for refining or for sale as crude corn oil.

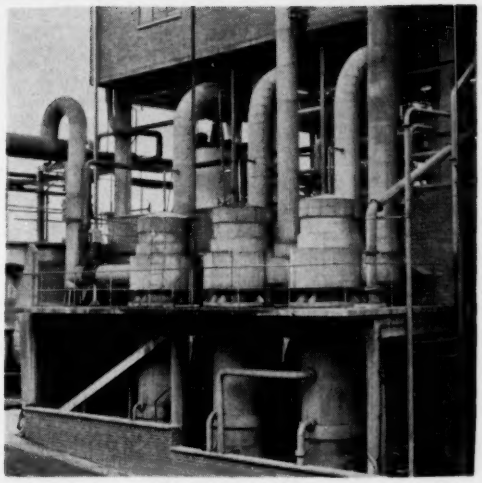
Fiber separated from the kernels by the reels is dewatered in centrifugal filters, then mixed with concentrated steep-water. Mixture is dried and ground. The gluten is concentrated eightfold, then filtered, dried and ground. Finally, fiber and gluten are blended to make gluten feed containing 25% protein, or meal with 42% protein.

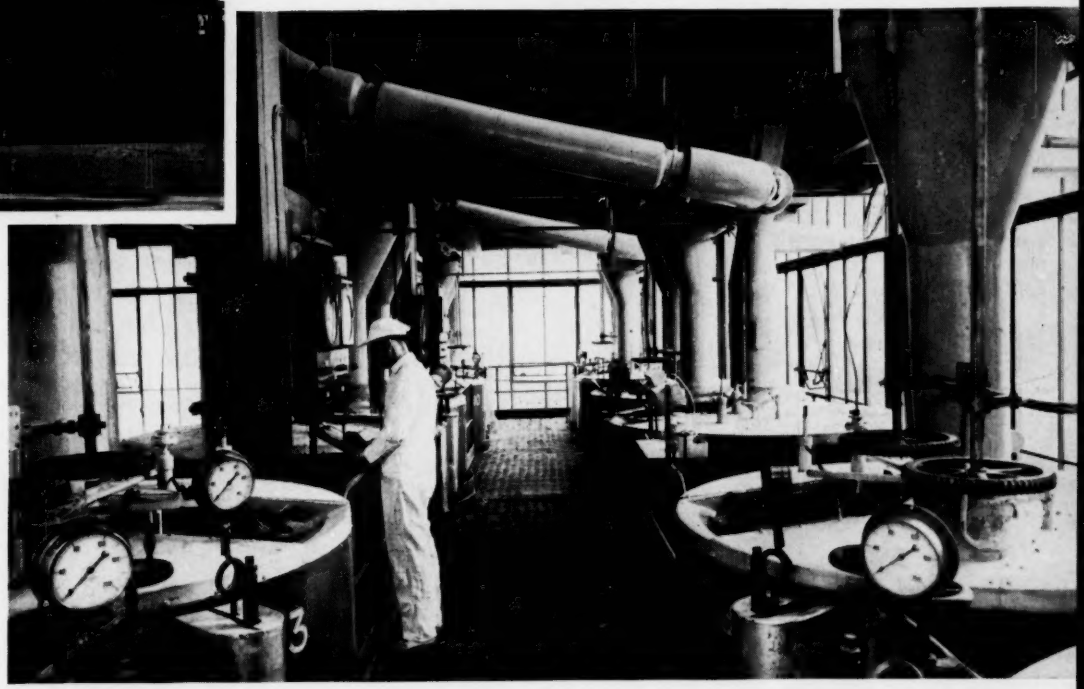


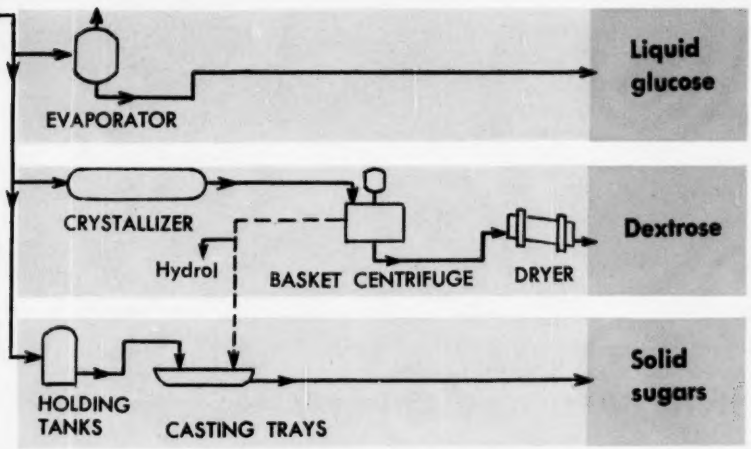
t) houses acidifiers, essively to convert ght are the cookers.

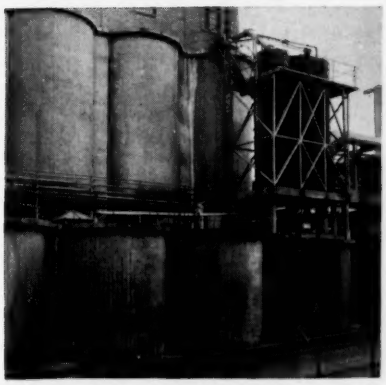
erial shelled maize.

Triple-effect evaporators concentrate spent liquor from steep-tanks. Product finds outlet in animal-feed applications.









Steep-tanks house initial processing step as kernels are softened at 124 F.

News from
National Carbon Company
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National Carbon representatives expand your engineering force

N. R. SWENSEN
Sales Engineer

Mr. Swensen is National Carbon's field sales engineer for chemical products in the State of Ohio, with headquarters in Cleveland.

As a member of National Carbon's application engineering group, he was active in the design and development of chemical processing equipment, particularly entrainment separators and hydrochloric acid absorption systems.

Mr. Swensen is a graduate of Michigan State University. He joined National Carbon Company in 1957.

Carbon Saddle Packing withstands abrupt temperature changes without spalling

Developed jointly by National Carbon Company and The United States Stoneware Company, carbon "INTALOX" saddle packing has a broad range of chemical applications. These saddles are recommended for hot alkalis, mixtures of hydrofluoric and sulphuric acids, hydrofluoric acid, and phosphoric acid—uses where chemical-resistant ceramics would be unsuitable. The unique carbon shape assures maximum contact surface between liquid and gas or between liquid and liquid. For data, write The United States Stoneware Company, 60 East 42nd Street, New York 17, N. Y.

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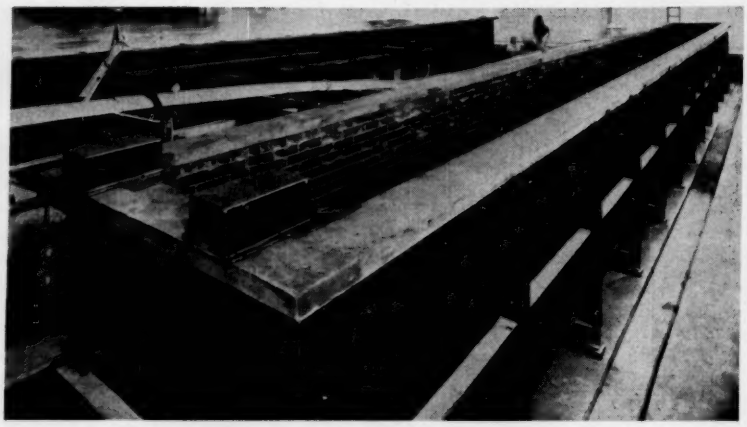
"NATIONAL" CARBON BRICK LININGS PROVIDE LONG SERVICE LIFE IN TOUGH CORROSION APPLICATIONS



Carbon brick combines unsurpassed resistance to corrosion, abrasion, and thermal shock, with dimensional stability. It is the ideal lining material for tanks, reactors, drain troughs and sumps handling difficult corrosive media.

Carbon brick are giving remarkably long service life in sulfate pulp digestors, nitric-hydrofluoric acid pickling tanks, wet process phosphoric acid digestor tanks, organic-sulphuric acid alkylation stripping towers and phosphoric acid concentrators.

The 9" x 4½" x 2½" series is stocked in 11 different shapes. In addition, circle brick 4½" wide x 2½" thick are made to order. For details, request **Catalog Section S-6215.**

"NATIONAL" POROUS CARBON Solves Corrosion Problem in Caustic and HF Filtering

Because of its chemical resistance to sodium hydroxide, hydrofluoric acid, and phosphoric acid, porous carbon is widely used for tubes and plates in filters handling these corrosives.

This versatile material is available in a wide variety of rod, plate, and block sizes. It can easily be machined and fabricated into tube, plate, and tear-drop diffusing and filtering elements.

In recent years, porous carbon has also been used as insulation for high-temperature furnaces and reactors, where resistance to corrosion and dimensional stability at high temperatures are essential.

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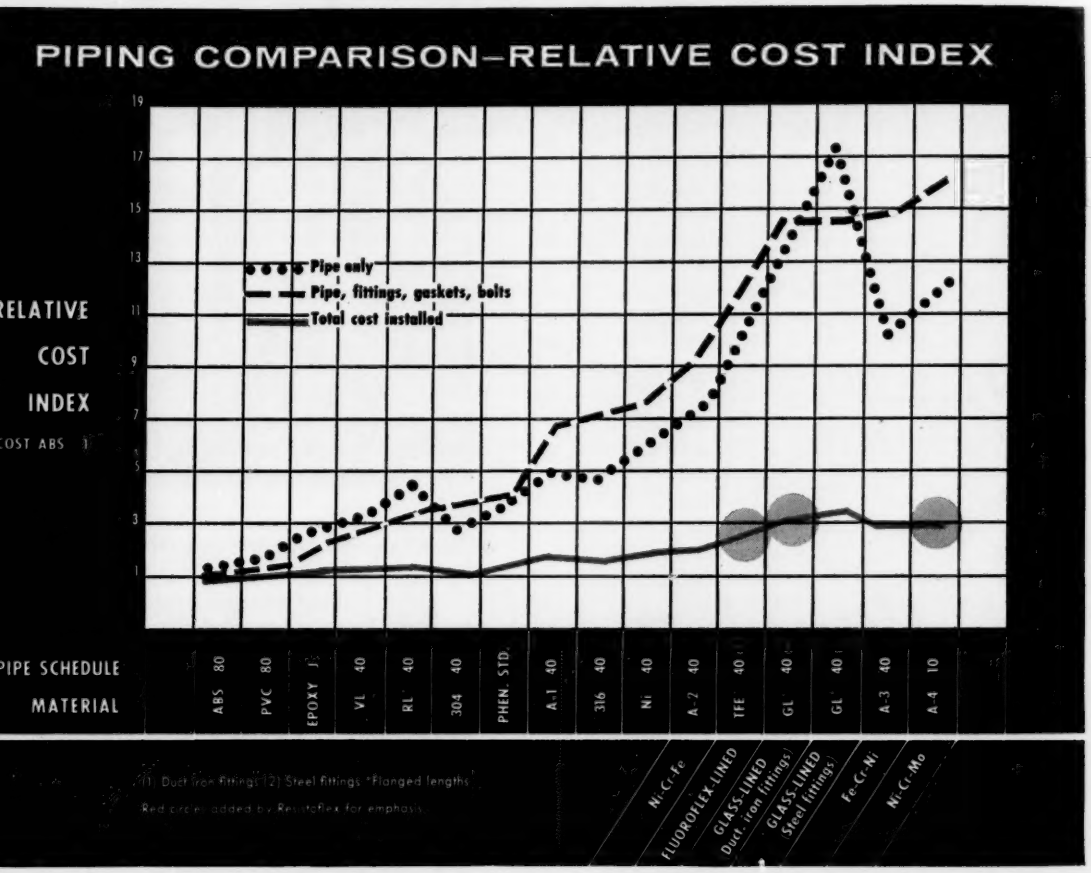

s chart from new documented study tells the whole story:

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lex*, the proprietary product manufactured solely istoflex, is fabricated Teflon at its best. Fluoroflex- eel pipe, because of its long service life, freedom orrosion, contamination, and product loss, is act- *placing* glass-lined, nickel alloy, and other cor- resistant piping materials.

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If you are planning a corrosion-resistant piping installation, can you afford to overlook economic facts like this? Write to Resistoflex Corporation for your copy of the complete analysis, today. Plants in ROSELAND, N. J., Anaheim, Calif., Dallas, Tex. Sales offices in major cities.

†DuPont T.M. *Resistoflex T.M.

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It does an excellent job in the non-metallics field for the uniform fine separation of cement, both raw mix and finished cement, as well as lime, gypsum and similar materials.

When operated in closed circuit with a grinding mill, it greatly increases output of the combined system.

- **The Whizzer principle gives sharper separation with higher recovery of fines, and also provides wide range classification to 99.9% minus 400-mesh materials.**
- **The extra large powerful fan develops maximum capacity rating of the separator.**
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- Valves that cannot wedge or jam
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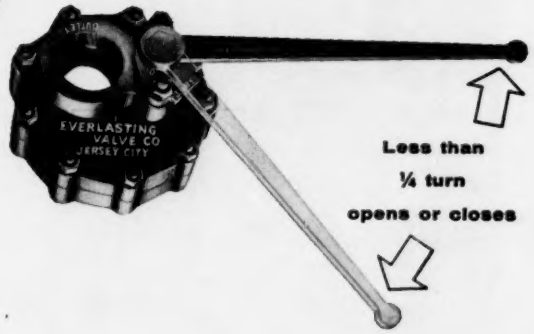

Less than
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BOILER BLOW-OFF
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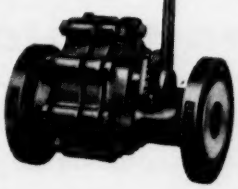
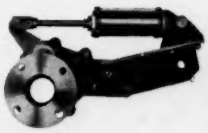


GENERAL SERVICE
Where drop-tight seal and full flow is essential.



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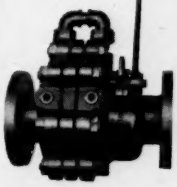
Can be remotely controlled, electrically or manually.



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Assures free flow of viscous materials.

WEIGHT-OPERATED
For automatic drains or emergency shut off.

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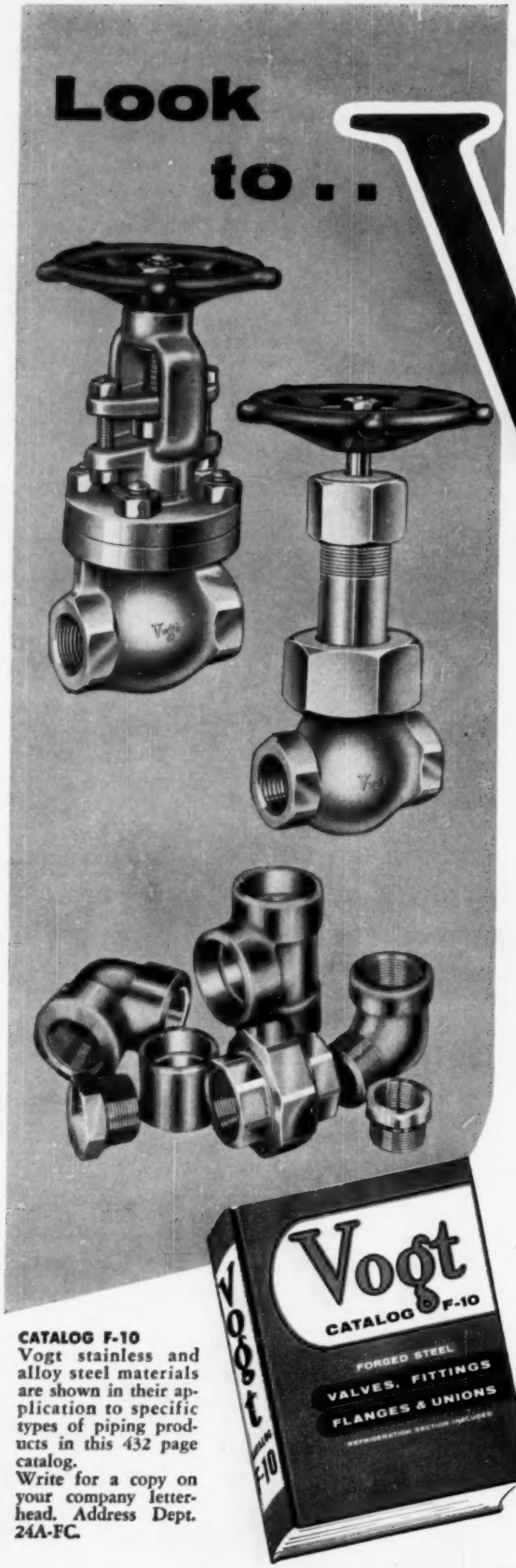

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Vogt stainless and alloy steel materials are shown in their application to specific types of piping products in this 432 page catalog.
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FOR FORGED STAINLESS AND ALLOY STEEL

Valves, Fittings and Unions

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BE SURE to consult the new Vogt Catalog F-10 when in need of top quality forged stainless and alloy steel piping products for severe operating conditions.

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A CE REPORT

The problem of developing better, more-powerful rocket propellants for military purposes and space travel is all part of the deadly game the world is playing. Engineers and researchers, many working for chemical process plants, are making an intensive effort at improving present materials and developing new propellants. To help you understand what is going on, here is an up-to-date look at where we stand in the chemical-rocket-propulsion field—with a critical examination of liquid and solid propellants.

Martin Co., (Titan Missile)

Chemical Rocket-Propulsion Systems

F. J. HENDEL, *Project Manager, Aerojet-General Corp.*

A chemical rocket engine has been described as a high-throughput, lightweight, flying chemical-process plant. A plant where tons per second of chemical reactants are converted mostly to hot, gaseous products at controlled rates. This airborne chemical process has come a long way in the last few years—in the direction of greater efficiencies and higher energies. Nobody has yet discovered the "ideal" propellant, and there is some doubt about its existence. But the search, carried out by a number of chemical companies, has resulted in some oxidizer-fuel combinations vastly superior to the old oxygen-kerosene or oxygen-alcohol propellants. Research work continues for even more powerful—

COMING: MORE ON ROCKET PROPULSION

This report, the first of two, deals with commercial or "standard" rocket propellants. The second part on more advanced chemical systems (hybrids, chemical-nuclear, etc.) will appear in our April 3 issue. Watch for it.

and probably more exotic—materials. But in this fast-moving field, this is a good time to take stock of what's been happening in chemical rocket propulsion—what improvements have been made and what is needed. (We will also discuss some of the simple ducted rocket-propulsion systems that use air or water to oxidize a fuel.)

Over-All Picture

However, first a few simple definitions are needed, because the measures of performance of a rocket are very different from that of an earthbound chemical plant.

Efficiency of a propulsion system is indicated by a parameter called specific impulse (I_s), which is equal to thrust (F) measured in pound force developed per pound mass of propellant consumed (fuel plus oxidizer) per second (w). Thus, the fundamental equation in jet propulsion is

$$I_s = F/w$$

where I_s is measured in lb. force-sec./lb. mass, abbreviated as lbf.-sec./lbm.* The higher the I_s, the lower the propellant flow rate required to achieve the same thrust.

How propulsion systems compare—Table I

	Directed Kinetic Energy in Jet/Gram of Exhaust Material, Kcal./Gm. (Approx.)	Specific Impulse, Lbf.-Sec./Lbm. (Approx.)
Steam, hot water	0.001–0.2	(0.1–1.3) x 10^2
Chemical rocket	0.2–3	(1.3–5 x 10^2
Chemical ducted propulsion	1–3	(3–12) x 10^2
Solar heating	1–4	(3–6) x 10^2
Nuclear fission		
Solid core	3–30	(5–15) x 10^2
Liquid core	11–40	(1–1.8) x 10^3
Gaseous core	350–650	(5–7) x 10^3
Charged colloid[c]	30–50	(1.5–2) x 10^3
Free radical	30–50	(1.5–2) x 10^3
Arc jet	11–350	(1–5) x 10^3
Ion jet[c]	350–3,000	(0.5–1.5) x 10^4
Thermonuclear fusion	(6–10) x 10^4	(6–9) x 10^4
Recombination ramjet	.....	.....
Hyperdrive[b]	.....	.....
Natural-force field systems[a]	.....	.....
Photon rocket	10^3	10^7
Plasma[c]	(1–6) x 10^4	(3–6) x 10^4

[a] Magnetic and electrostatic fields, antigravity devices.
[b] Faster-than-light drives.
[c] Magnetohydrodynamic devices (MHD).

Table I shows the performance of different propulsion systems, indicating where chemical propellants fit into the over-all picture. Many other systems have been proposed, from nuclear to photon propulsion. These will be discussed in a forthcoming article.

Generally, a high directed kinetic energy in the jet per gram of exhaust material produces a high specific impulse. Lowest performance is found in gas and water rockets. These rockets, not shown in the table, have an I_s in the 70-80 lbf.-sec./lbm. range. In order of increasing I_s are:

Gas and hot water.
Steam.
Chemical (rocket and ducted propulsion).
Solar heating (conceptional).
Nuclear fission, including isotope decay devices (not operational).
Charged colloid† (not operational).
Free radical (not operational).
Arc jet (not operational).
Ion jet† (not operational).
Plasma† (not operational).
Thermonuclear fusion (conceptional).
Recombination ramjet or interplanetary aeroduct (conceptional).
Photon (conceptional).

The highest specific impulse, 10^7 lbf.-sec./lbm., by the photon rocket, lies in the realm of fantasy. This rocket would use "light" as the propellant. That photons possess momentum is demonstrated by the pushing away of comet tails as they pass near the strong photon radiation of the sun—solar sailing of space stations or space rocket will work on the same principle.

As the directed kinetic energy in a jet, per gram of exhaust material increases, I_s increases. With this increase, however, comes an increase in complexity of the rocket, lack of proper construction materials and of know-how in developing the higher I_s systems.

Benefits gained by advanced propulsion systems having higher I_s than the chemical rockets are obvious from the graph in Fig. 1. Shown here is the mass ratio (the ratio of final mass of the rocket vehicle after the burnout of propellant to initial mass of the rocket vehicle) for various space missions vs. I_s.

The missions shown in the graph are in terms of velocity increment (ΔV) as miles per second (mps). A velocity increment (increase of the velocity, V, of the total vehicle after burnout of a given stage) of 2 mps. is needed for one-way interplanetary probe flights started from orbit about the earth. A velocity increment of 7 mps. is required for a 973-day, round-trip flight to Mars. A velocity increment of 16 mps. is needed for a Earth-Mars orbit-to-orbit flight with

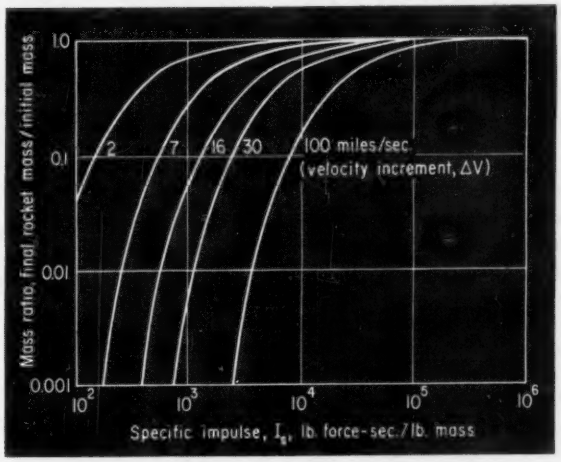
* I_s is also measured in seconds; this comes from the expression $I_s = C/g$ (see Table II) where C is in ft./sec. and g in ft./sec.^{2} But the unit "second" here is misleading as it is usually considered a measure of time.[3]

† These are magnetohydrodynamic devices (MHD) also called magnetofluid mechanic, magnetogasdynamic and hydromagnetic. These and arc-jet devices belong to the family of electrical propulsion.

a 30-day wait at Mars and a total trip time of 1 yr. A velocity increment of 30 mps. is called for to reduce the Mars trip to 3 mo.

If a mass ratio of 0.03 is reasonable, then I_s values of at least 100, 300, 750, 1,400, and 4,600 are required for velocity increments of 2, 7, 16, 30, and 100 mps., respectively. Chemical rockets are limited to the first two values because their highest I_s is less than 500 lbf.-sec./lbm.

Velocities required for space missions—Fig. 1



Chemical Propulsion

Chemical-propellant performance can be evaluated on the basis of over-all performance of the complete rocket. Therefore, important performance parameters are: specific impulse (I_s) (or specific thrust), effective exhaust velocity (C), characteristic exhaust velocity (C') and specific propellant consumption (w_s). Interrelation of basic rocket parameters is shown below.

Performance of a propellant combination is determined by the following propellant properties:

- High chemical energy per unit of propellant mixture is desirable (high chamber temperature).
- Low-molecular-weight product gases of the propellant combination are desirable. This results from using fuels rich in combined hydrogen or other lightweight atoms that in turn are liberated during the reaction. A low molecular weight is obtained if an excess of hydrocarbon fuel is used (so that a significant portion of the produced hydrogen gas will not combine with oxygen). The best mixture ratio for many propellants is, therefore, not necessarily the stoichiometric one, but usually a rich mixture containing large proportion of low-molecular-weight reaction products.

In the rocket, heating value of the total propellant (not just the fuel) and the molecular weight of the product gas are equally important.

This has three significant implications:

- Relative performances of different rocket propellants need not be in the same order as their combustion temperatures, and frequently are not.
- Heat of combustion of a compound may, by itself,

How basic rocket properties are related—Table II

	C	C'	C_F	F	I_s	L'	w_s
Effective exhaust velocity C (ft./sec.) =	———	$C'C_F$	$C'C_F$	Fg/w_t	$I_s g$	$P_c V_c C_F g/L' w_t$	g/w_t
Characteristic velocity C' (ft./sec.) =	C/C_F	———	$Fg/C_F w_t$	$P_c A_t g I_s/F$	$I_s g/C_F$	$P_c V_c g/L' w_t$	$P_c A_t g/F w_s$
Thrust coefficient C_F =	C/C'	C/C'	———	$F/P_c A_t$	$I_s g/C'$	$L' w_t I_s/P_c V_c$	$w_t/P_c A_t w_s$
Thrust (theoretical) F (lb.) =	$w_t C/g$	$P_c A_t I_s g/C'$	$P_c A_t C_F$	———	$w_t I_s$	$P_c V_c C_F/L'$	w_t/w_s
Specific impulse I_s (lbf.-sec./lbm.) =	C/g	$C'C_F/g$	$P_c A_t C_F/w_t$	F/w_t	———	$P_c V_c C_F/L' w_t$	$1/w_s$
Characteristic chamber length L' (in.) =	$P_c V_c C/FC'$	$P_c V_c g/w_t C'$	$P_c V_c C_F/F$	$P_c V_c C_F/F$	$P_c V_c C_F/w_t I_s$	———	$P_c V_c C_F w_s/w_t$
Specific propellant flow (consumption) w_s (lb./lb.-sec.) =	g/C	$P_c A_t g/FC'$	$w_t/P_c A_t C_F$	w_t/F	$1/I_s$	$L' w_t/P_c V_c C_F$	———

A_t Throat area of rocket (thrust) chamber, in.²
C Effective exhaust velocity of propellant gases, ft./sec.
C' Characteristic velocity of propellant gases, ft./sec.
C_F Thrust coefficient.
F Thrust of the rocket chamber, lb.
g Acceleration of gravity, ft./sec.²
I_s Specific impulse (lb. thrust per lb. propellant per sec.).
L' Characteristic length of rocket chamber, in.
P_c Pressure of combustion in rocket chamber, psia.
V_c Volume of rocket chamber (up to the throat), in.³
w_s Specific flow (consumption) of propellant, lb./lb.-sec.
w_t Weight flow rate of propellant (oxidizer-fuel), lb./sec.

be a poor or misleading indication of its performance potential as a rocket fuel.

• Importance of low molecular weight effectively limits the atomic composition of rocket fuels to the light elements in the first two rows of the periodic table. Presence of elements heavier than aluminum is generally detrimental.

High density of the propellant is an important design factor. For this reason, solid propellants are effective competitors of liquids, although solids generally have lower specific impulses. Since high hydrogen content in a propellant is desirable, most useful rocket fuels are relatively rich in hydrogen.

Specific impulses of rocket propellants now in operation or in development and research, range from about 200 to 400 lbf.-sec./lbm. at sea level with higher values at greater altitudes.

Velocity attained by a rocket-powered vehicle is directly proportional to the specific impulse, and maximum vertical range is proportional to the square of the specific impulse. The horizontal range is also proportional to the square of the specific impulse over relatively short ranges. However, because of the curvature of the earth, the horizontal range increases much more rapidly with increasing specific impulse at longer ranges. For example, at a 5,000 nautical-mile nominal range, a 1% increase in specific impulse increases the range by approximately 7%.

Chemical propellant rockets are classified as follows:

- Liquid rockets, which use only liquid propellants.
- Solid rockets, which use only solid propellants.
- Hybrid rockets, which use both liquid and solid.
- Underwater rockets, which use either solid, liquid, both solid and liquid, or gaseous propellants.

Liquid Propellants

The term liquid propellant embraces all of the various liquids used, and includes:

1. Oxidizer (liquid oxygen, nitric acid, fluorine).
2. Fuel (alcohol, kerosene, hydrazine).
3. Inert additive (water).

There are many combinations of liquid propellants possible for combustion. However, an ideal combination that does not have any undesirable characteristics has not yet been discovered. Almost every liquid propellant, especially every liquid oxidizing agent, has at least one or more undesirable properties (such as corrosiveness, cryogenic requirements).

Usually two propellants are used in a rocket motor: an oxidizer and a fuel. These are bipropellant rockets, where propellants are housed outside of the combustion chamber and are fed to it through an injector. Reaction of the two propellants occurs within the combustion chamber.

A monopropellant contains either an oxidizing agent and combustible matter in a single substance, or a compound that will decompose exothermically in the presence of a catalyst. An example of the former is nitromethane, an example of the latter is hydrogen peroxide, with silver as the catalyst.

Monopropellants are stable at ordinary atmospheric conditions but decompose and yield hot gases under heat and pressure. The monopropellant, like the bipropellant, is housed outside the combustion chamber and is fed through an injector. The feed system is usually simple because there is only one liquid.

Selecting Liquid Propellants

Important factors in the selection of liquid propellants are:

1. Specific impulse of the oxidizer plus fuel combination.
2. Density. The higher the density, d, the smaller the rocket tanks; hence, the "density impulse," $I_s d$, should be as high as possible.
3. Hypergolicity. The rocket is simplified when the fuel and the oxidizer ignite spontaneously on contact; diergolic or nonhypergolic propellants require an auxiliary ignition system.
4. Vapor pressure. A high-vapor-pressure liquid propellant may be a serious problem in a closed container.
5. Freezing point. Present Armed Services requirements often specify −65 F. freezing point.
6. Viscosity. Low viscosity helps convey the liquid to the thrust chamber; negligible changes of viscosity with temperature will result in better control of the mixture ratio during temperature changes.
7. Shock sensitivity. Propellants should not detonate when exposed to shock, heat or impact.
8. Corrosiveness. Corrosive propellants require special materials of construction.
9. Toxicity. The lower, the better; if exhaust gases are toxic it is difficult to carry out static tests.
10. Contamination sensitivity. Some propellants become unstable when contaminated with dirt, water, hydrocarbons.
11. Storability. Only noncryogenic propellants and those that do not decompose in storage are storable.

Theoretical performance of the most-used liquid-bipropellant combinations is shown in Table III, which is based on a chart by Rocketdyne.[28] The following values for different oxidizer-fuel combinations are given:

$r_{wt.}$ and $r_{vol.}$—Optimum mixture ratios of oxidizer to fuel by weight and by volume, respectively.

d— Bulk density, g./cc., of the propellant combination calculated from the formula

$$d = \frac{r_{wt.} + 1}{r_{wt.}/d_{oxid.,sat} + 1/d_{fuel}}$$

Density at the boiling point is used for those oxidizers or fuels that boil below 68 F. at 1-atm. pressure.

T_c—Thrust chamber temperature, °F.

C'—Characteristic exhaust velocity, ft./sec.

M_c—Average molecular weight of combustion products at T_c.

I_s and $I_s d$—Theoretical maximum specific impulse and density impulse, respectively, calculated for the optimum mixture ratio $r_{wt.}$

Assumed Conditions

All I_s were calculated for shifting equilibrium—consideration was given to changes in chemical composition during expansion of the gaseous products in the engine nozzle from the throat to the exit (such expansion takes place in a fraction of a second). Frozen equilibrium calculation considers a fixed chemical composition of the gaseous products throughout expansion in the nozzle, and thus makes the I_s determination somewhat easier. I_s and I_sd for the frozen equilibrium are slightly less than for the shifting equilibrium. All calculations are usually performed on large digital computers.

Other assumed conditions for the data in Table III were:

Optimum nozzle expansion ratio (exit area)/(throat area); infinite contraction ratio (chamber area)/(throat area); adiabatic combustion; isentropic expansion of ideal gas; combustion chamber pressure of 1,000 psia.; nozzle exit pressure of 14.7 psia. (other pressures could be used).

A theoretical specific impulse calculated at higher altitudes (with nozzle exit pressures less than 14.7 psia.) is higher than sea-level I_s. Exhausting to vacuum results in the highest theoretical I_s, and it is called "vacuum specific impulse."

To approximate theoretical I_s and I_sd at other cham-

Liquid bipropellant combinations offer variety of properties—Table III[29]

Oxidizer	Fuel	Wt. Oxidizer/ Wt. Fuel, $r_{wt.}$	Vol. Oxidizer/ Vol. Fuel, $r_{vol.}$	Bulk Density, d, G./Cc.	Chamber Temp., T_c, °F.	Characteristic Velocity, C', Ft./Sec.	Avg. Mol. Wt. Combustion Products, M_c	Specific Impulse, I_s, Lbf.-Sec./ Lbm.	I_sd
Oxygen	Ammonia	1.40	0.84	0.89	5100	5865	19.8	294	261
	75% ethyl alcohol	1.43	1.08	1.01	5355	5480	24.1	279	281
	92.5% ethyl alcohol	1.73	1.23	0.99	5640	5605	24.1	287	285
	Hydrazine	0.90	0.80	1.07	5660	6235	19.3	313	335
	50% UDMH-† 50% hydrazine	1.30	1.03	1.02	5890	6160	20.6	312	319
	Hydrogen	4.02	0.25	0.28	4935	7980	10.0	391	172
	Hydyne*	1.73	1.31	1.02	5990	6035	21.8	306	312
	RP-1**	2.56	1.82	1.02	6150	5920	23.3	300	308
	UDMH†	1.65	1.14	0.98	6010	6115	21.3	310	304
Fluorine	Ammonia (H)††	3.29	1.48	1.18	7715	7155	19.3	357	422
	Hydrazine (H)	2.30	1.54	1.31	7955	7245	19.4	363	478
	Hydrogen (H)	7.60	0.35	0.45	6505	8365	11.8	410	305
Chlorine trifluoride	Hydrazine (H)	2.77	1.53	1.51	6550	5995	23.2	294	444
	50% UDMH-50% hydrazine (H)	2.89	1.42	1.45	6385	5795	24.5	287	417
	Hydyne (H)	2.98	1.40	1.43	6220	5555	26.1	276	395
	RP-1 (H)	3.20	1.42	1.41	5890	5140	29.1	258	386
	UDMH (H)	3.03	1.31	1.38	6305	5630	25.8	280	388
95% hydrogen peroxide-5% water	Hydrazine (H)	2.17	1.54	1.26	4675	5655	19.5	282	355
	50% UDMH-50% hydrazine (H)	3.35	2.12	1.25	4760	5580	20.5	279	351
	Hydyne (H)	4.68	2.83	1.27	4765	5485	21.3	276	352
	RP-1	7.35	4.18	1.30	4785	5405	22.1	273	355
	UDMH (H)	4.54	2.53	1.24	4800	5530	21.7	278	346
Red fuming nitric acid (15% NO_2)	Hydrazine (H)	1.47	0.95	1.28	5090	5690	20.8	283	365
	50% UDMH-50% hydrazine (H)	2.20	1.26	1.27	5250	5580	22.4	279	358
	Hydyne (H)	3.11	1.70	1.31	5295	5425	24.1	273	359
	RP-1	4.80	2.48	1.35	5355	5275	25.8	268	363
	UDMH (H)	2.99	1.51	1.26	5340	5490	23.7	276	350
Nitrogen tetroxide	Hydrazine (H)	1.34	0.93	1.22	5390	5845	20.9	292	357
	50% UDMH-50% hydrazine (H)	2.00	1.24	1.21	5590	5725	22.6	288	348
	Hydyne (H)	2.71	1.61	1.22	5650	5580	24.1	282	347
	RP-1	4.04	2.26	1.25	5745	5440	25.7	276	348
	UDMH (H)	2.61	1.42	1.18	5685	5650	23.6	285	339

* Hydyne is a 60% (by weight) mixture of UDMH and 40% diethylenetriamine (also called UDETA).
** RP-1 is a hydrocarbon fuel (kerosene) in accordance with Specification MIL-F 25576B(USAF).
† UDMH is unsymmetrical dimethyl hydrazine (also called Dimazine).
†† H—hypergolic.

Note: Specific impulse is measured at shifting equilibrium at 1,000 psia./14.7 psia.

ber pressures, use the following multiplication factors:

For Pressure, Psia.	Multiply by
1,000	1.00
900	0.99
800	0.98
700	0.97
600	0.95
500	0.93
400	0.91
300	0.88

The "delivered specific impulse," also called "experimental or actual I_s," is approximately 90% of the theoretical specific impulse.

Popular Liquid Propellants

Established combinations in current use or development are LOX and RP-1 (kerosene), LOX and hydrogen, N_2O_4 and hydrazine, and minor variations of these. Some are storable, others cryogenic.

It is pertinent to point out that propellants contribute in a large measure to the reliability of a rocket engine. Cryogenics usually require added handling otherwise not needed for storables. Low temperatures associated with cryogenics represent areas of unreliability. But, in general, the cryogenic propellants yield higher specific impulses than do storables.

The common oxidizer, red fuming nitric acid (with up to 22% N_2O_4) when inhibited by HF is called IRFNA (inhibited RFNA). Its composition usually is: HNO_3, 82.9%; NO_2, 14.0%; H_2O, 2.5%; HF, 0.6%. White fuming nitric acid (WFNA) contains 98% HNO_3, 2% H_2O.

The freezing point of IRFNA is −65 F., while it is −43 F. for WFNA. Although the boiling point of WFNA is 187 F., and IRFNA 136 F., the latter has a higher specific gravity 1.57 (vs. 1.51 for WFNA). Specific impulse for WFNA with RP-1 is approximately 3 sec. less than for IRFNA with RP-1.

Maximum density fuming nitric acid (MDFNA) contains up to 52% N_2O_4. Density of MDFNA is greater than density of either HNO_3 or N_2O_4.

Fluorine and chlorine trifluoride are excellent liquid oxidizers. However, handling problems and highly toxic exhausts limit their use in rockets.

Cooling the Engine

Thrust chambers and nozzles of liquid rockets are usually cooled, except for very short duration firings. Cooling of rocket combustion chambers includes: regenerative, film, transpiration (sweat), ablation.

Regenerative cooling involves circulating one of the propellants through cooling passages around the chamber before injection and combustion of the propellant in the chamber. The propellant actually assists in cooling the thrust chamber walls. Any increase in internal energy of the liquid propellant from this heat exchange can be calculated as a correction to the heat of reaction, but the effect on rocket performance is slight.

A review of methods for using liquid propellants as rocket engine coolants is given by Bartz.[22]

Heat transfer is usually by convection at low heat fluxes and by radiation at very high fluxes. At the low heat fluxes—below the boiling point of liquid—there is a liquid laminar boundary layer. At higher heat fluxes, which correspond to a greater wall-liquid temperature difference, the laminar layer disappears and nucleate boiling of the liquid close to the hot wall starts. Between radiation and nucleate boiling regions there is an intermediate temperature difference that causes an unstable gas film on the hot wall, resulting in a low rate of heat transfer.

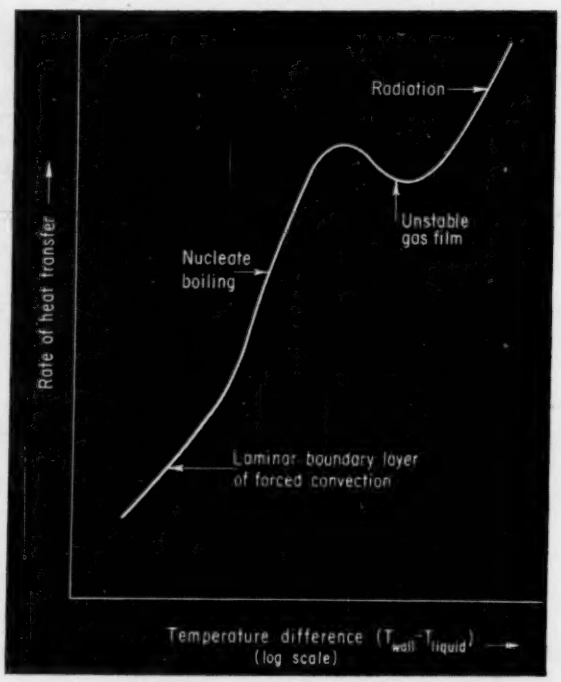
Fig. 2 shows the rate of heat transfer vs. temperature difference between flowing liquid and wall.

Film, Sweat or Ablative?

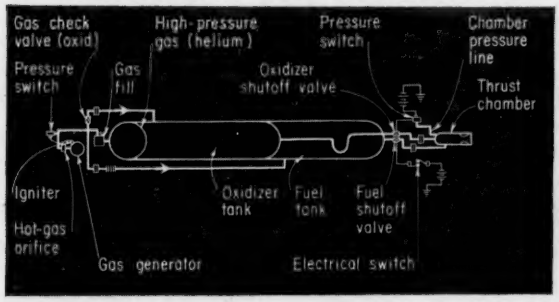
Film cooling involves introducing a thin fluid film that covers and protects the exposed hot wall surfaces from excessive heating. The film is introduced by injecting small quantities of fuel or oxidizer in a large number of places along the inner chamber surface forming a protective film. This is effective because considerable heat is required to evaporate the liquid that keeps the inner surface of the combustion chamber cool. Film cooling generally results in a slight decrease in rocket performance because the coolant film is not burned efficiently.

Transpiration cooling—sometimes called sweat cooling—is a special type of film cooling. The coolant is introduced into the thrust chamber through a porous wall material and distributed uniformly over the heated surface. There has been considerable difficulty in get-

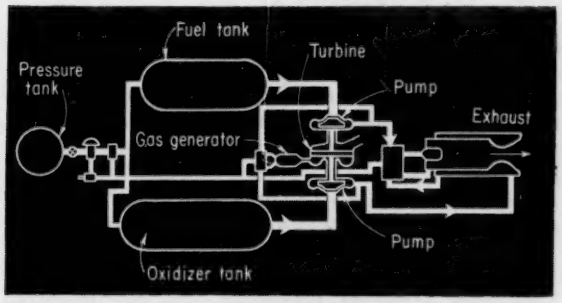
Heat transfer through wall to liquid—Fig. 2



Typical pressured bipropellant rocket—Fig. 3



How pump feeds liquid-rocket chamber—Fig. 4



ting a uniform coolant distribution along a porous surface because the pressure drop across the inner thrust chamber wall varies, particularly at the nozzle.

Ablation cooling is a method of cooling the main body of structural material by covering it with another solid material, such as a plastic, which melts, evaporates or decomposes. For best results, the latent heat of melting, evaporation or decomposition should be as high as possible.

Liquid-Propellant Feed Systems

The liquid-propellant rocket uses: tanks to store or house the fuel and oxidizer, or monopropellant; a feed mechanism for forcing the propellants into the thrust chamber; a power source to furnish the energy required by the feed mechanism; a control device for regulating the propellant flow rates.

A large variety of feed systems have been used at one time or another. However, they can be reduced to two basic types: (1) gas pressurized systems (also called pressure-fed propellants) and (2) turbopump systems (also called pump-fed propellants).

Within each basic system, many modifications are possible.

Gas Pressurized Systems

The gas pressurized systems can use a third tank containing gas under high pressure, with regulators in the lines to the propellant tanks. It is important that pressurizing gas (He, N_2, air) contains no moisture. This prevents icing of the regulator (due to adiabatic expansion, the temperature of the gas can drop well below −100 F). A size savings is gained by using high-pressure tanks (up to 4,400 psi.) but materials of construction must be thick to withstand such pressures.

Solid-propellant cartridge (solid-gas generator) can also supply pressure. This consists of a small chamber in which a cartridge of some solid propellant can be burned to release gas in large quantities at moderate pressure and temperature.[81]

Another approach uses a combination of the two techniques (Fig. 3). This method can avoid low temperatures of the expanded gas.

Spontaneous ignition of part of the main propellants is a fourth pressurizing technique. A controlled, small amount of propellants is mixed to produce a chemical reaction (liquid gas generator). The gaseous reaction products provide pressure for the propellant tanks. A problem with this scheme: raising the propellant gases to a pressure greater than that in the tanks from which the gases come. This must be done so exhaust products will enter the main propellant tanks with sufficient pressure to move the propellants to the thrust chamber. Solution to this problem requires an auxiliary device such as a small pump.

Turbopump Systems

The turbopump rocket system delivers propellants to the thrust chamber at elevated pressures using gas-turbine-driven pumps. The turbopump rocket system (see Fig. 4) operates with the following major components:

- Pumps, to pressurize the propellants.
- Turbines, to drive the pumps (an alternate to the turbine-driven pump is the hydraulic or electric-motor-driven pump).
- Gas generators, to generate hot gases for turbine power.
- Gas pressurizes, to prevent vacuum formation in the propellant tanks when propellant is being pumped out. The gas, which may come from the gas generators and must be compatible with the fuel or oxidizer, provides the main liquid propellants with proper net positive suction head (NPSH) needed for the pump.

Turbopump rocket systems are generally used on high-thrust, long-duration units. For this type of operation, they are usually lighter than gas-pressurized rockets. Weight of the turbopump is essentially independent of duration of operation while the weight of gas-pressurization sources is directly related to duration.

The main propellant tanks contain liquid oxidizer and fuel at low pressure. Low pressure permits lightweight tankage, and results in a lower ratio of total missile to propellant weight. Many missiles employ the tanks as part of the system structure and are designed so critically that a small positive tank pressure

(10-40 psig.) must be maintained to prevent collapse of the tank assembly.

Starting and Driving

The gas generator, actually a small thrust chamber, generates gases to drive the turbopump. A special starting device is required to start the gas generator. This may be a small gas-pressurized auxiliary propellant supply that furnishes propellants to the generator, or a small charge of compressed air that starts rotation of the turbine. Small solid-propellant gas generators can also be used to drive the turbopump. Continued operation frequently uses the bootstrap technique: a portion of the high-pressure propellant liquids exiting from the pumps is returned to the gas generator. Special provisions must be made to control the flow of propellant to the generator.

The turbopump turbine is driven by gases from the gas generator, and exhausts the gases at a lower energy level. In recent years, exhaust gases have been used to provide a small amount of thrust for vernier roll control, or for heat exchangers to vaporize liquids and preheat gases, or for auxiliary power supply. The pumps receive low-pressure propellants at the suction side and perform work on the propellants, raising their pressure to required level for injection into the thrust chamber.

In a typical liquid-turbopump rocket-propulsion system, the propellant supply from the missile tanks is often used for other purposes in addition to producing thrust. These uses will, to some extent, affect the over-all missile performance but, effects will be small, since propellant consumption is small when compared with that used directly for producing thrust.

In general, liquid propellants in a rocket engine are used for one or more of the following in addition to producing thrust; driving turbopump feed system; driving auxiliary power unit (APU) to generate electric and hydraulic power required for guidance; tank pressurization.

Pros and Cons of Cryogenics

Oxygen, fluorine and hydrogen as liquids are cryogenic propellants. Only liquid oxygen (called LOX or sometimes LO_2) is being used extensively now, backed up by a vast amount of experience. Air-transportable LOX generators with capacities up to 1,000 lb./hr. are available. These are brought to launching sites that do not have a large stationary LOX plant nearby.

Liquid fluorine and liquid hydrogen belong to the advanced propellants and will be discussed in more detail with other cryogenic propellants in a forthcoming report on advanced chemical propulsion.

Canned Propellants

Storable or prepackaged liquid propellants (PPLP), also called "canned", are propellants that can be kept in the liquid rockets for 2 yr. or longer, and thus provide instant readiness similar to solid rockets.

Most storables use a hypergolic propellant combination to avoid elaborate ignition and control systems. The engine, therefore, is quite simple and has high reliability. Other advantages are: safety, missile mobility, wide temperature-cycling capacity, minimum requirements for ground support equipment and maintenance (service), and low cost of the rocket and of the over-all system.

Specifications for storable propellants have been recently relaxed. They now have to perform either in tropics and medium climate, or under arctic conditions, but not in both. The rocket may be kept in a protected environment at a suitable temperature prior to launching. Controlled environments involve keeping the rocket engines (or the whole rocket or missile) in insulated shipping containers, refrigeration envelopes, heating blankets, or in air-conditioned silos.

The newer storable propellants can theoretically deliver I_s ranging from 300 to 340 lbf.-sec./lbm. (1,000 psia. exhausted to 14.7 psia.) as compared with 300 sec. for LOX and RP-1.

Common storable propellants are: unsymmetrical dimethyl hydrazine (UDMH), mixed amines such as Aerozine (approximately 50% N_2H_4 and 50% UDMH), unsymmetrical diethylenetriamine (UDETA) or Hydyne (60% UDMH and 40% diethylenetriamine), ammonia, N_2O_4, H_2O_2, FRNA, MDFNA, mixed oxides of nitrogen (MON). MON-15 contains 15% NO as freezing-point depressant and 85% N_2O_4—it has a freezing point of −25 F.

To achieve maximum simplicity, storable-liquid systems use pressure pumping, which eliminates moving parts, numerous valves and powered pumps. To achieve positive displacement and avoid pumping vapor instead of fluid, collapsible tanks or membranes are popular for expelling the liquids.

Only hypergolic propellants have been used so far. They avoid ignition and combustion-stability problems. Tanks are pressurized with small, simple solid-propellant gas generators.

The hypergolic combination gives smooth combustion over a wide range of combustion chamber pressures. Ability to start and stop engines using these propellants is another big advantage.

Some liquid propellants stored in sealed tanks have better storage characteristics than the best available solid propellants. For instance, the UDMH-IRFNA system has been stored successfully for 3 yr. at 165 F.

How Do They Perform?

Performance of monopropellants is given below.

	Density, G./Cc.	Chamber Temp., °F.	Avg. Mol. Wt. Chamber Products	I_s	I_sd
Hydrazine	1.00	1,500	12.0	196	196
UDMH	0.784	1,250	18.8	162	127
Ethylene oxide	0.882	1,600	22.0	180	159
90% H_2O_2	1.387	1,382	22.1	147	204
100% H_2O_2	1.45	1,855	22.6	163.4	236
N-propyl nitrate	1.058	2,100	16.6	173	183

All I_s are experimental values except for 90% and 100% H_2O_2.

Solid Propellants

As defined by the name, the solid-propellant rocket is made of a solid cast or extruded material and is wholly contained within the combustion chamber. Solid-propellant rockets have many and varied uses:

- Artillery. To fire warheads from a gun or launcher tube for short ranges up to about 5 mi. The dividing line between artillery and missiles is generally one of range.
- JATO, boosters and sustainers. JATO is the type of solid rocket used to assist manned aircraft on takeoff. A booster is usually the first stage of a multistage rocket engine or a ramjet engine. Sustainer is usually the second-stage rocket engine. The booster and sustainer can be either solid- or liquid-propellant units (although to date most boosters have been solids).†
- Missiles. The term missiles is generally restricted to units having a range in excess of five miles. Further differentiations are usually based on the purpose of the missile. For example, surface-to-surface, surface-to-air, air-to-air, air-to-ground, intermediate range ballistic missile (IRBM), intercontinental ballistic missile (ICBM), are common designations.
- Research vehicles for upper air research or interplanetary exploration.

Solid Burning Surface

For a large thrust, mass flow has to be large. This can be achieved by a large burning surface. Similarly, a low thrust with a correspondingly longer duration can be obtained if the exposed burning area is small. Since a given combustion chamber will be able to hold only a limited amount of propellant, the variation of thrust and burning rate has to be obtained by varying the geometrical arrangement of the propellant charge to increase or decrease the burning surface. A number of different propellant grain arrangements are shown in Fig. 5.

In a restricted (insulated) burning solid rocket, the propellant charge usually fills the complete chamber and burns only on one surface. The thrust, for an end-burning grain, is proportional to the chamber cross-section, and duration is proportional to charge length. This charge uses the combustion space most efficiently. Restricted burning units have a nearly constant burning area.

† In the Tartar motor,[21] the normal two-stage booster and sustainer are compressed into one compact unit. This single power plant has a high-thrust short-duration booster that serves to launch and accelerate the missile to a supersonic speed. After burnout of this booster, the lower-thrust, longer-duration sustainer portion of the motor maintains the missile speed until sustainer burnout. The Tartar's dual-thrust, dual-grain solid propulsion system has many advantages. It is simple and more reliable because there is only one ignition system, fewer metal parts and the attachment and separation system is eliminated. The over-all safety of this system is increased since the possible hazard from a falling burned-out booster case is eliminated. Shipboard logistics and storage problems are minimized because the missile occupies much less space than others now in use and is relatively easy to handle and transport. The complete weapon is about 15-ft. long and slightly over 1 ft. in dia.

An unrestricted grain has usually one or more cylinders of hollow or special cross-section. By making the charge hollow (the hole is called perforation), it is possible to keep the burning surface close to a constant, because, as the outside circumferential area decreases during the burning, the inside bore increases in surface area. Thrust depends on the exposed burning surface. Duration is a function of web thickness (distance between inside and outside surface). Because of the necessary air spaces, the unrestricted burning charge does not use all the chamber volume.

How to Design Grain

A rule-of-thumb for high-performance solid rockets states that diameter in inches will be about one to two times the burning time in seconds. The length of the rocket depends upon its designed thrust. Typical length-diameter ratios lie between 4 and 8. Outside these limits, total impulse per unit volume tends to drop.

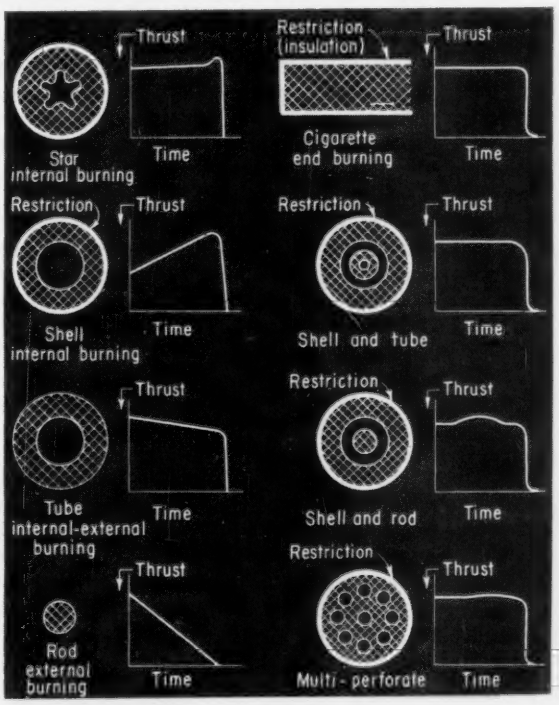
Once burning time and diameter are set, the other rocket features can be estimated on the basis of available information. Only the general characteristics of solid propellants need be considered.

The burning rate r_b (in./sec.) of a propellant usually is pressure-sensitive, as is shown by the common empirical equation:

$$r_b = bp^n$$

where b is the proportionality constant (cu. in./lb.-

Solid shapes determine performance—Fig. 5



sec.); p is pressure (in psia.); and n is the pressure exponent, which may vary from zero to 0.7 (a typical value being 0.4).

As the burning surface changes during combustion, so does the rate of gas generation. However, equilibrium chamber pressure builds up quite rapidly because of the exponential behavior of the burning rate. With a typical burning-rate exponent of 0.4, pressure may climb to 160% of nominal design pressure. Naturally, propellants with low burning rate exponents are desirable.

Similarly, a low temperature coefficient is desirable. For solid propellants, these coefficients (based on pressure) usually are 0.1-0.4%/°F. At 165F., the pressure might be 50% above the ambient value.

By equating the propellant consumption rate w (lb./sec.) with the gas flow from the nozzle throat, we can calculate instantaneous chamber pressure P_c (psia.):

$$F = I_s w = C_F A_t P_c$$
$$\text{or } w = r_b \rho A = (g/C') A_t P_c$$

where ρ is propellant density (lb./cu. in.); A_b burning surface (sq. in.); C' characteristic exhaust velocity (ft./sec.); A_t, throat area (sq. in.); C_F thrust coefficient; and $g = 32.2$ ft./sec.^{2}

Types of Solid-Propellant Burning

In a normal burning solid propellant, pressure rises rapidly with time, and varies according to the burning surface exposed. When combustion ends, pressure will decrease rapidly. Burning can be regressive or progressive. The latter is often incorporated by design of the propellant configuration (perforation).

Erosive burning can be seen as a pressure peak at the start of a firing—the peak is usually rounded. Magnitude of the peak will be higher for low-temperature firings because erosive burning is more severe at the lower burning rates obtained at low temperatures.

A small erosive peak is not serious, and its magnitude is greater for low-temperature firings, where operating pressure is low. Thus, strength of the chamber is sufficient to prevent any bursting.

Unstable burning appears as a sudden increase in pressure, which remains at a higher level than normal for various periods of time and then decreases again to normal. Unstable combustion vibration resulting in acoustical resonance is called resonant burning.

Erosive and resonant burning have been subjects of extensive studies.[24]

How to Ignite Solid

Igniters for solid-propellant rocket units are almost exclusively pyrotechnics. (For liquid rockets, igniter is usually an electrical spark plug or glow plug). In some cases, the igniter pellet is put into the forward end of the chamber so ignition gases will sweep past the entire propellant grain before reaching the nozzle. Igniters are often held within the propellant charge, and electric wires reach them through the nozzle. Where wire and igniter fragments may cause damage, the igniter is built into the chamber wall and wires are introduced through a pressure-tight seal.

A pyrotechnic igniter usually consists of an electrically heated wire, surrounded by a small amount of primer (usually less than 1 g.). Primer is a temperature-sensitive substance that will ignite and burn when heated. The main igniter charge is immediately adjacent to the primer. It gives a hot flame, which ignites the main rocket motor charge. Since the igniter housing is inserted through the nozzle, it is often made of a plastic that will burn and therefore will not form an obstruction to gas flow.

Two Solid Propellants

There are two general types of solid chemical propellants presently in use.

One is the homogeneous propellant, where oxidizer and reducer are present in a single, or colloidal, phase. The most significant development in this area came with the blending of nitrocellulose and nitroglycerine to form double-base propellants. Stabilizers and plasticizers are added to improve shock stability and improve physical properties.

The composite propellant, often called heterogeneous, is composed of oxidizer and reducer, present in two distinct phases. This may be a mechanical mixture of finely powdered materials with a binding agent. Composite propellants are commonly used in solid-propellant rockets.

The organic binder or fuel matrix and solid crystalline oxidizers are usually in weight proportions of about 20-25% fuel-binder and 75-80% oxidizer.

Fuel-binders used:

- Amorphous. Asphalt (obsolete), polyisobutylene. Original standard JATO used a special-grade asphalt and potassium perchlorate. Polyisobutylene is a synthetic rubber currently used in England with ammonium perchlorate oxidizer.
- Polycrystalline. Nitrocellulose, polyvinyl chloride.
- Crosslinked. Vinyl polyester, polysulfide (Thiokol), polyurethane, hydrocarbon rubbers (GRS or butadiene styrene, GRI).

Fuels (nonbinders) are powdered light metals like aluminum or magnesium.

Oxidizers used include: potassium perchlorate ($KClO_4$) or nitrate (KNO_3); ammonium perchlorate (NH_4ClO_4) or nitrate (NH_4NO_3);

Additives used are: plasticizers, antioxidants, polymerization catalyst, burning rate additives, (all normally of a proprietary nature).

Propellants containing $KClO_4$ have the highest burning rates, while propellants containing NH_4NO_3 have the lowest.

The highest theoretical I_s of presently used solid propellants is approximately 250 lbf.-sec./lbm. at 1,000 psia. chamber pressure exhausted to 14.7 psia. The highest experimental (actual) I_s for the same conditions is approximately 240 lbf.-sec./lbm.

Mechanical properties are nearly always those of a hard-rubber-like, rigid mass, but there are flexible or

granular grains and charges used in service. The rigid solid-propellant grains and charges can be machined on a lathe to fit the chamber or sheath, and grains can be drilled for pressure control (progressive or regressive combustion). If a solid-propellant grain is the only piece of solid propellant carried within a particular rocket combustion chamber, it is also identified as the solid-propellant charge.

Significant properties of solid propellants are: low molecular weight of the combustion gas, high density of the solid propellant, stable combustion, low isobaric flame temperature range for both operation and storage, a satisfactory burning rate, low burning-rate exponent, low pressure and temperature sensitivity values, low or no toxicity either before or after combustion, high exhaust velocity when properly expanded, low hygroscopicity, low cost, and a high rate of generation (high content of chemical energy in relation to a low molecular weight).

Processing Solid Propellants

There are several acceptable and satisfactory methods of producing a solid-propellant grain.

Selection of a method sometimes depends upon available equipment and extent of the production program. Often, performance requirements and chosen ingredients (fuel and oxidizer) designate what process will be required because of the physical properties and characteristics of the solid-propellant mixture at various steps in the process. For example, a solvent-processed propellant uses different equipment and techniques, as compared with a solventless-processed mixture.

Popular processing methods include: casting, compression molding, dry extruding, machining (turning and drilling), packing, pressing, solvent extruding, and solventless extruding.

With the casting method, a fluid mixture is poured into a casting mold and cured under controlled temperatures. The solid-propellant grain hardens and can be withdrawn or removed from the casting mold. If an axial passage (perforation) has also been formed in the grain, the core (mandrel) is withdrawn next.

Need Coarse and Fine

Incoming raw materials usually need some conditioning to make them suitable for a particular process. This includes purification, drying, grinding and screening.

One of the most important operations is grinding. Most of the oxidants in composite propellants are crystalline. To provide the highest possible propellant density, all particles in the propellant should be as close together as possible. Using the analogy of concrete, a combination of coarse and fine particles will generally produce the highest density. Therefore—in selecting grinding equipment—particle size, shape and time required for the operation will determine the type of grinder to be used.

Ball mills generally produce the greatest variety of particle sizes, but the process is slow and screening must follow. Hammer mills, though expensive, generally produce the smallest particle sizes with the greatest speed. For obvious safety reasons, oxidizer and reducer are ground separately.

The conditioned materials flow to a metering center where the correct amount of material is measured out, either by weight or volume. Weighing is usually a tedious batch technique, while volume measurements are rapid and adaptable to continuous flow. For the most part, the propellant industry has used the batch technique.

Mixing Can Be Hazardous

Before final mixing, it is desirable to do some preliminary blending. Solids are blended by simple mixing. Miscible liquids are blended by stirring. Immiscible liquids can be mixed in equipment specially constructed to produce the desired product.

Final mixing is regarded as a very hazardous operation, since oxidizer and reducer are brought together for the first time. Mixing must be thorough to insure a uniform mass. A uniform mixture will largely depend on materials used, type of mixer, and length of mixing operation.

The final operation depends largely on nature of the finished, mixed propellant. For fluid mixtures, casting either directly into the prepared rocket motor or into some other mold is possible. For drier mixtures or for putty-like consistencies, extrusion- or pressure-casting may be necessary. Dry materials require compression molding. An additional operation such as curing, fusion, or solvent removal may be necessary to achieve the desired product.

Processing should produce a fuel-binder with high oxidizer concentrations. Fluidity is necessary to allow casting. The process should not cause evolution of volatile materials and high shrinkage rates. Curing time should be short to give high production rates.

In processing double-base propellants, the nitrocellulose is dehydrated at the propellant plant and then nitroglycerine and solvent (ether and alcohol) are added. This is mixed to form a colloid along with plasticizers, stabilizers and additives. The colloid in then pressed hydraulically in several stages, at pressures of from 3,000 to 3,500 psi. Final forming into grains is by extrusion at pressures of from 2,500 to 4,000 psi. Solvent is removed by drying or heating in warm air—final solvent drying is with warm water.

Essentially, in the solventless process, nitrocellulose blends with nitroglycerine or diethylene glycol dinitrate and plasticizers (such as diphenylurea) at high temperatures to form a workable plastic. This method allows production of large rocket grains—impractical with solvent methods since solvent removal from the interior of large grains is almost impossible.

Continuous mixing plants for cast solid propellant have recently been constructed in the U. S. Their capacity is such that they will be able to replace all batch-mixing stations. Continuous mixing plants are much safer because the dangerous mixture of oxidizer and fuel at any one time in the equipment is present

only in relatively small quantities compared to batch.

Liquid Vs. Solid

Many articles have been written, many symposia and panel discussions held, and many arguments fought on the subject "liquid vs. solid rockets."

Gains of solid rockets within the last few years have generally been more spectacular than those of liquid systems. Achievements in technology and applications of solid-rocket plants have been outstanding. This is due to the work of chemists and chemical engineers who developed solid-propellant grains with high specific impulse and excellent physical properties. For practical military applications, there is a tendency to prefer solid over liquid systems because of:

- Simplicity. A maximum of two to four moving parts as compared with the hundreds or even thousands in a modern liquid engine.
- Compactness. Higher density of solid propellants permits lighter and smaller rockets for the same mission compared with a corresponding liquid rocket.
- Reliability. Because of intrinsic simplicity, reliability of the solid is over 99% while that of the liquid is approximately 97%.
- Safety. Except for fire hazards, solids are safe. There is no problem of toxicity or corrosiveness.
- Control. Control of the solid-rocket system is through grain design and other means; thrust termination is obtained by nozzle separation, burst ports; thrust vector control is through auxiliary nozzles, jeterators, jet vanes or vernier engines.
- Cost. Although solid-rocket engines are usually more expensive than liquid, the development cost of a given solid engine is about one-fifth that of a similar liquid one. Production costs are about the same.

Liquid engines are usually used when long firing times and restarting are necessary requirements.

Compare liquid and solid with same specific impulse—Table IV[36]

	Solid Rocket	Liquid Rocket
I_s, lbf.-sec./lbm	235	235
Diameter, ft	5	5
Impulse, lb.-sec	4,557,000	4,557,000
Propellant tanks, lb	.....	1,000
Engine, lb	.....	2,053
Propulsion system wt., lb	1,050	3,053
Propellant, lb	19,392	19,392
Loaded propulsion system, lb	20,442	22,445
Empty wt., lb	6,834	8,837
Launch wt., lb	26,226	28,229
Inert weight, (empty wt.-propulsion system wt.), lb	5,784	5,784
Mass ratio (see Fig. 1)	0.95	0.86
Length, total propulsion system, ft	9.7	31

Performance Limitations

However, solid rocket propellants have certain limitations that prevent wider application of these units. Performance of the propellant charge is very sensitive to ambient temperature variations; beyond certain limiting chamber pressures, operation is no longer stable.

From sad experience, it is known that initial temperature of the grain will materially affect its performance. On a hot day, a solid-propellant motor will operate at higher chamber pressure and thrust than on a cool day. Firing duration will be shorter, but the total impulse will not be changed greatly. This indicates that the initial temperature of the grain has a decided effect on the burning rate and that weather conditions have to be considered when exacting performance requirements are to be met. (The temperature sensitivity of liquid-propellant motors is not severe and can easily be corrected—for example, by inserting of restricting orifices in the propellant feed lines.)

Some solid propellants are limited to a fixed and rather small operational temperature range for reasons other than temperature sensitivity. At very cold temperatures, some of the propellant charges become brittle and tend to crack, particularly if the propellant was warmed after exposure to very cold surroundings. An uneven temperature distribution, or the differential expansion between chamber, liner material and propellant charge may also cause such cracking. Any crack in the grain increases the burning area and, therefore, mass flow and chamber pressure. This leads to an overloading of the chamber walls and often to a chamber failure.

At low temperatures, the rocket may fail to ignite or may burn only intermittently. Overheating of the propellant charge prior to firing will often make it weak and plastic, so that it is unable to withstand the sudden high chamber pressure or the acceleration that the vehicle might undergo. Subsequent failure is again due to an undesired increase in the burning area.

Limited by Pressure

There is also a practical upper and lower pressure limit for the satisfactory operation of a solid rocket unit. Below a certain pressure, the combustion becomes unstable; in fact, certain propellants will not sustain burning at atmospheric pressure. This, of course, means that the chamber pressure of solid units will be relatively high. On the other hand, the lower combustion limit gives some sort of safety feature to solid propellants; for once the chamber explodes, fragments of certain solid propellants will be relatively harmless since they will not sustain combustion at ambient pressure. (This is not true of most liquid propellants.)

Pressure is determined by the throat area. When the throat area exceeds a certain value, chamber pres-

sure is low and combustion will be unstable. This throat area is called the critical throat area; actual throat area always has to be smaller. Chamber pressure is often selected to be just above the limiting combustion pressure, to keep the wall thickness and chamber weight to a minimum.

Above a certain upper pressure limit (burning limit), the burning rate will increase so rapidly that a detonation will occur, which usually shatters the chamber. This pressure is very high (above 6,000 psi.).

Many solid propellants deteriorate with storage. Some decompose, and certain chemicals are often added to inhibit decomposition. Others absorb moisture, which softens and weakens the charge. Decomposition of various double-base propellants (ballistic and related types) is self-catalyzing. Chemicals, such as diphenylamine, are usually added to neutralize the effect of the initial decomposition products.

The advantages and disadvantages of the two propulsion systems are indicated in Table V. A comparison between performance and system parameters of solid and liquid engines developing the same specific impulse (235 sec.), is shown in Table IV.

Pros and cons of liquid and solid rockets—Table V

	Liquid Rockets	Solid Rockets
Theoretical I_s at 1,000/14.7 psia.	Reaching 400 sec.	Reaching 255 sec.
Simplicity.	No	Yes
Reliability.	97–98%	Over 99%
Combustion start on large units can be programmed.	Yes	No
At present, higher thrust-level of large engines.	Yes	No
Duration,	Long	Presently 60 sec. max.
Thrust vector control.	Yes (best is gimballed thrust chamber)	Yes (with difficulty)
Restart capability.	Yes (with hypergolic propellant or secondary igniter)	No
Auxiliary power unit (APU).	Not required (gas turbine provides electric and hydraulic power)	Required
Gas turbine products used for control.	Yes	——
Scale-up of thrust or engine size.	Easy	Difficult
Sensitivity to temperature or vibrations.	Not too sensitive	Large engines sensitive (grain may crack)
Installing instrumentation, etc.	On empty units (safe)	On live units
Shipment of large units.	Fairly easy (hardware only)	Difficult
Cooling of nozzle and thrust chamber.	Difficult	No
System presently possible for manned rocket.	Yes	No (restart not possible)
Field servicing.	Dangerous	Easy
Static firing prior to launch.	Often required	No
Combustion instability.	Cannot be cured simply or empirically; expensive and tedious propellant injector re-design sometimes necessary	Not too well understood
Turbine pumps required for larger units.	Yes	No
Large high-altitude nozzles.	Difficult to design and build if they must be cooled	——
Some chambers need critical metals.	Yes	No
Instant readiness.	Only with PPLR (prepackaged liquid rockets)	Yes
Mass ratio (mass of propellant/mass of loaded power plant.	Not good (0.85)	Excellent (over 0.9)
Static (captive) test stands.	Expensive	Simple
Can be built cheaply and plentifully in small sizes.	No	Yes

Ducted Jet Propulsion

Ducted jet-propulsion systems are quite different from liquid or solid rockets. The surrounding fluid, either air or water, is ducted through the device and accelerated to a greater momentum by mechanical or thermal means prior to ejection.

The aerial-ducted jet-propulsion systems are represented by the turboprop, turbojet, pulsejet, and ramjet, all well-developed and currently in use. Other ducted devices will be described in a forthcoming article.

The water-ducted jet-propulsion systems are represented by the hydropulse, hydroduct (underwater ramjet) and the hydroturbojet.

General operation of the ducted systems is relatively simple. Each unit carries its own fuel supply but uses the oxygen (or water) in the working fluid to support combustion of the resulting mixture.

Aerial-ducted units are called air-breathing engines and their operation is restricted to the thin atmospheric blanket surrounding the earth. For practical purposes, ducted engines are limited to peak altitudes of about 100,000 ft., where the air pressure is 0.1603 psia. Flight higher than 150,000 ft., where air pressure is 0.0212 psia., is impossible; air density is so low that combustion is starved for lack of oxygen. Therefore, thrust decreases with altitude as the air density decreases. In actual practice, the rocket is not as limited as might be supposed, since thrust increases with altitude as the back pressure of the surrounding atmosphere decreases.

Aerial Jets Take Various Forms

Turbojet (Fig. 6)—Here, the working fluid is taken

in at the front, compressed using a turbine-driven axial compressor. Fuel is injected, and the resulting mixture burned and expanded through the turbine and the exhaust nozzle. Momentum of the ducted air is thus increased producing a continuous forward thrust. The turbojet engine may have its thrust output increased by substantial amounts if additional fuel is burned in the turbine exhaust ahead of the exhaust expansion nozzle. This is known as afterburning, or thrust augmentation. The turbojet has static thrust because the axial compressors can be run by an auxiliary starter to force air into the combustion chambers.

Turboprop (Fig. 7)—This is a turbojet plus a propeller in front of the air intake. The propeller shaft is connected through gears to the turbine and compressor shafts. Both turbojets and turboprops are used extensively in aircraft.

Ramjet (Fig. 8)—Incoming air is ram-compressed in the diffuser, and fuel is injected, burned and expanded through the exhaust nozzle. Momentum of the ducted air thus increases, producing a continuous forward thrust. This unit is frequently termed the athodyd (aerodynamic thermodynamic duct). The ramjet has no static thrust because there is no means of forcing air into the system except by boosting the unit to an initial velocity with some other type of propulsion system.

Pulsejet (Fig. 9)—The previous units rely on a continuous flow of fluid. The pulsejet, however, operates on an intermittent principle. Air enters the inlet valve bank, fuel is injected, and the resulting mixture is ignited and expanded through the tailpipe. The momentum of the intermittently ducted air is thus increased and produces a pulsating thrust.

Underwater Propulsion

Varieties of underwater jet engines are rockets (solid, liquid and hybrid) and ducted jets, such as the hydroduct (underwater ramjet), the hydropulse, and the hydroturbojet.

Because of the increasing importance of deep underwater operation, the solid rocket is becoming more important. The standard rotating propellers offer advantages of greater range for shallower operations. But speed is limited by body cavitation and by power-density limits. Rockets and similar jet systems offer excellent underwater speeds for reduced ranges.

Propulsion problems under water are largely due to high resistance to forward motion, high ambient pressure, cavitation, and availability of suitable propellants. For moderate speeds (less than 90 knots), propellers turned by conventional underwater engines are superior but, just as in air, for high speeds the jet engines produce more power.

Undersea warfare is, at present, the only application made of underwater propulsion. However, the potential value of submerged bodies for overseas transport is beginning to be recognized.

The hydroduct, as described by Gongwer[28] is an underwater ramjet using a heat source to flash sea water to steam at ram pressure. Developed by Aerojet-General, the device uses a specially developed non-gassing propellant. This propellant provides a highly concentrated source of heat energy, and steam formed by sea water in contact with the flame contains virtually no uncondensables.

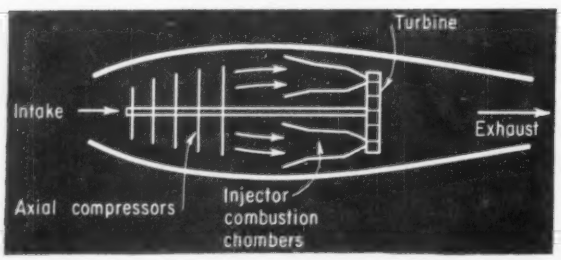
In the hydroduct, sea water enters the nose diffuser, passes around the propellant (which burns endwise) and goes into the flame. Turbulators produce a uniform mixture of steam and combustion products. Steam generation is at ram pressure. Like other ramjets, the device must be boosted to running speed (speeds in excess of 100 knots are not unusual). The hydroduct is sensitive to depth, since for a given speed, the pressure ratio decreases with increasing depth.

A variation of the hydroduct is the hydroturbojet. This unit uses a turbine-driven pump to force sea water into the combustion chamber. Fuel is a water-reactive chemical like molten lithium. With a pump in addition to ram pressure, the device can operate at slower speeds and accelerate from rest.

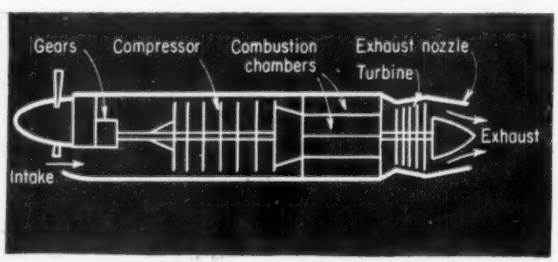
Hydropulse Powerful and Efficient

The hydropulse (Fig. 10) is composed of a straight pipe barrel that enlarges slightly at the forward end and joins a reed-type inlet check valve. A diffuser sits forward of the valve. The axis is normally aligned with the direction of motion, and fuel, which in one case is a liquid alkali metal, is injected intermittently

Turbojet is simple and efficient—Fig. 6



Turboprop uses turbojet to drive propeller—Fig. 7



into the water-filled duct downstream of the valves.

This system is powerful and efficient but it has certain inherent drawbacks at high speeds. The intermittent intake through the diffuser affects external flow, and above 60 knots at shallow depth there is a cyclic external cavitation. Using multibarrels from the same diffuser helps to some extent but not enough.

Specific fuel consumption, using molten lithium, is as low as 5-lb. of fuel per thrust-horsepower-hour. Allowing for a propulsive efficiency of about 60%, this is equivalent to about 3 lb. per shaft-horsepower-hour on a rotating power plant. This is better than an underwater rocket power plant at the present time, but it is not good enough to override the practical difficulties.

Underwater Rocket

The underwater rocket has a high thrust per unit frontal area, which is determined by the diameter of the combustion chamber or casing and nozzle. This makes it admirably suitable for high underwater speeds (above 90 knots). The liquid rocket is not suitable for deep running because of limitations on the chamber pressure and pressure ratio. However, the solid rocket can operate at very high chamber pressures and therefore operates well at great depths. Hybrid rockets have also been used.

Although rocket speeds underwater are necessarily lower than in air, the high power and available thrust can be very effective. Because of high drag, the distance of coasting is also limited, so rocket motors are used as sustainers and a high-acceleration boost phase is necessary for trajectory stabilization.

Effect of depth introduces complexities on the nozzle-exit-to-throat-area ratio. If the area ratio is correct for shallow running, it will be too large for deep running, and considerable drag increase and loss of thrust will occur. However, a rocket nozzle can be designed for operation over a wide range of depths.

Other Aerial Systems: Gas, Water, Steam

A compressed-gas rocket is the simplest type of rocket engine. All that is needed is a compressed-gas cylinder, chamber or tank, provided with a nozzle. Release of compressed gas through the nozzle gives a thrust. Such rockets are used as auxiliary thrust devices for position control in large rocket engines.

Hot Water, Steam

Hot-water rockets[10] can deliver a specific thrust of about 70-80 lbf. resulting in a specific impulse of 70-80 lbf.-sec/lbm. A hot-water rocket resembles a boiler. The rocket chamber is filled prior to launching with hot water under pressure. During World War II, the Germans used this rocket as a RATO* device for their Messerschmidt fighters. But instead of filling the rocket with hot water, the chamber was loaded about three quarters full with cold water, which was then heated prior to launching. The water, when heated, expanded and filled most of the chamber. During flight, the thrust level and specific thrust of the device continuously decreased because a portion of the energy of the remaining water had to be used to form steam.

Steam Is More Powerful

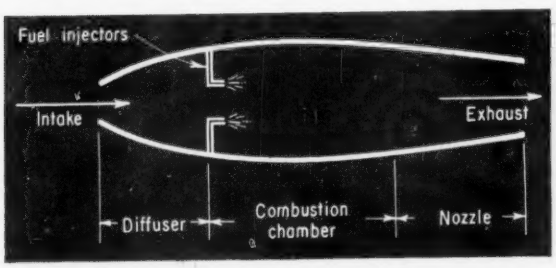
Steam rockets are filled with very hot water (1,000-1,300 F.) under approximately 600 psia.; they can deliver a specific thrust between 120 and 135 lbf. (I_s = 120-135 lbf.-sec/lbm.)

The hot-water rocket differs from the steam rocket; water expands rather than steam. Hot water vaporizes as it expands through the nozzle. Water at the nozzle exit may contain as much as 25% steam. Much of the energy of the water is used to produce steam, but the energy of hot water is considerably less than that of steam. This explains the relatively low specific thrust of the hot-water rocket. However, the greater propellant-loading density of water makes use of the hot-water rocket much more attractive than steam for RATO applications. The hot-water rocket may contain as much as 0.8 mass fraction of propellant, while a similar steam device might have a mass fraction of propellant of only 0.1.

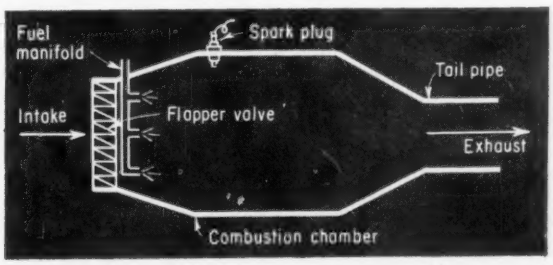
German scientists are currently working on both hot-water and steam rockets (and technical publications indicate that serious consideration is being given to the use of water as a working fluid in nuclear rockets). In the field of hot-water rockets, a German

* RATO-Rocket-assisted-takeoff. Usually JATO refers to solid rockets and RATO to liquid.

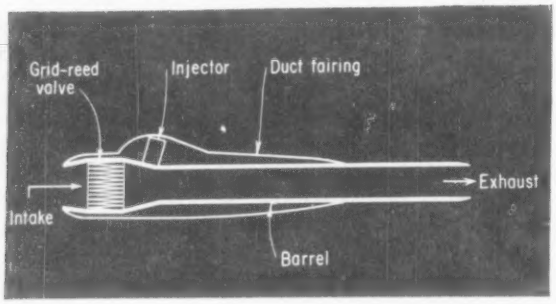
Ramjet must be boosted to initial velocity—Fig. 8



Pulsejet operates on intermittent flow—Fig. 9



Hydropulse uses water, liquid metal—Fig. 10[25]



engineer is currently developing a 400,000-lb.-sec. total impulse device (at the direction of the German Ministry of Transportation) for possible use as a mail and freight rocket. The cost of developing hot-water and steam rockets is only one twentieth that of developing chemically propelled rockets of equal size.

In this country, however, interest has been slow in coming. Experiment Inc., Richmond, Va., has reportedly fired several steam rockets in an attempt to test their suitability for meteorological applications. The Navy has shown some interest in the RATO application. Cole[37] recently proposed water as the working fluid for a nuclear pulse-rocket.

It may be advantageous to use the steam rocket in re-entry vehicles for attitude control during the terminal phase of operation. Water converts to steam by aerodynamic heating during re-entry. The steam is vented, as needed, through one or more of four nozzles. Excess steam is vented uniformly through four additional nozzles. This method might be superior to compressed-gas systems because the working fluid is stored in a dense form under a low pressure.

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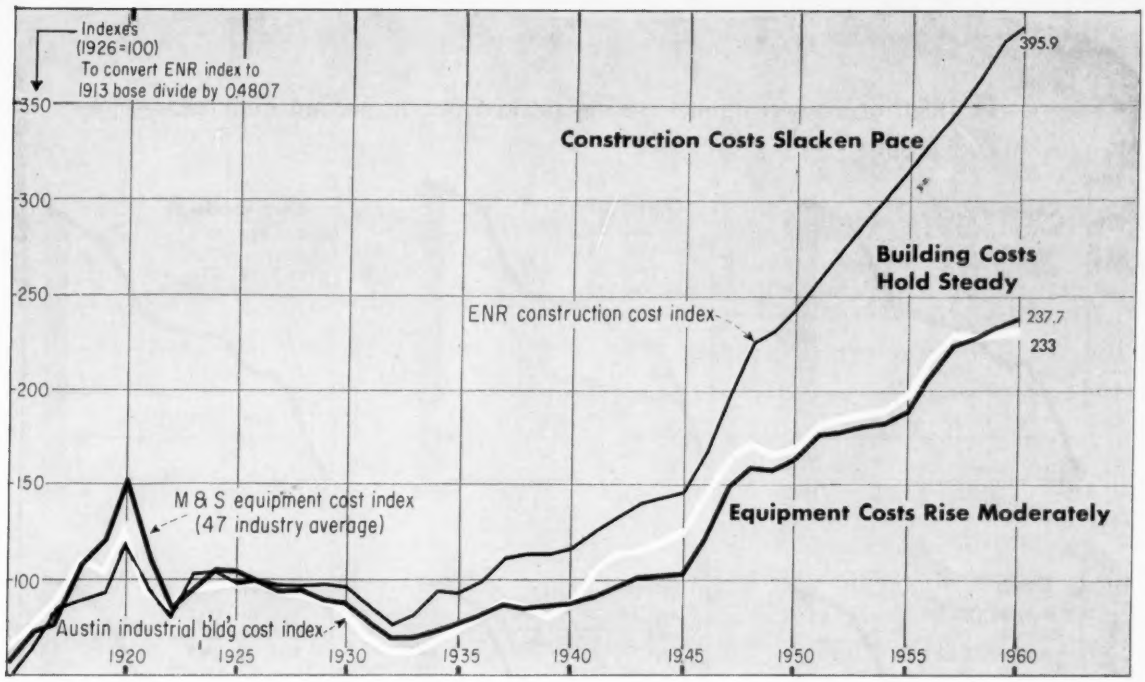


Costs Hesitate in Upward Trend

Average equipment costs in the CPI rose again in 1960 but the rise was not uninterrupted. In most cases, costs peaked out during the second quarter, then declined for the rest of the year.

Plotted above is a 47-industry average of equipment cost indexes, prepared by the evaluation engineering firm of Marshall and Stevens, Inc., Los Angeles. Basis of each of the individual indexes upon which the average is based and the method of weighing the average are described on pages 124-6 of our November '47 issue in an article by the late R. W. Stevens, partner of the firm.

Plotted on the same grid are the Austin Co.'s index of industrial building costs, and the *Engineering News-Record* index of heavy construction costs. The former has remained constant for five consecutive quarters.

The M & S annual average index of comparative equipment cost for eight process industries and four related industries are tabulated below and on the following page. Extending from 1913-60, these averages are supplemented by quarterly figures in the individual charts.

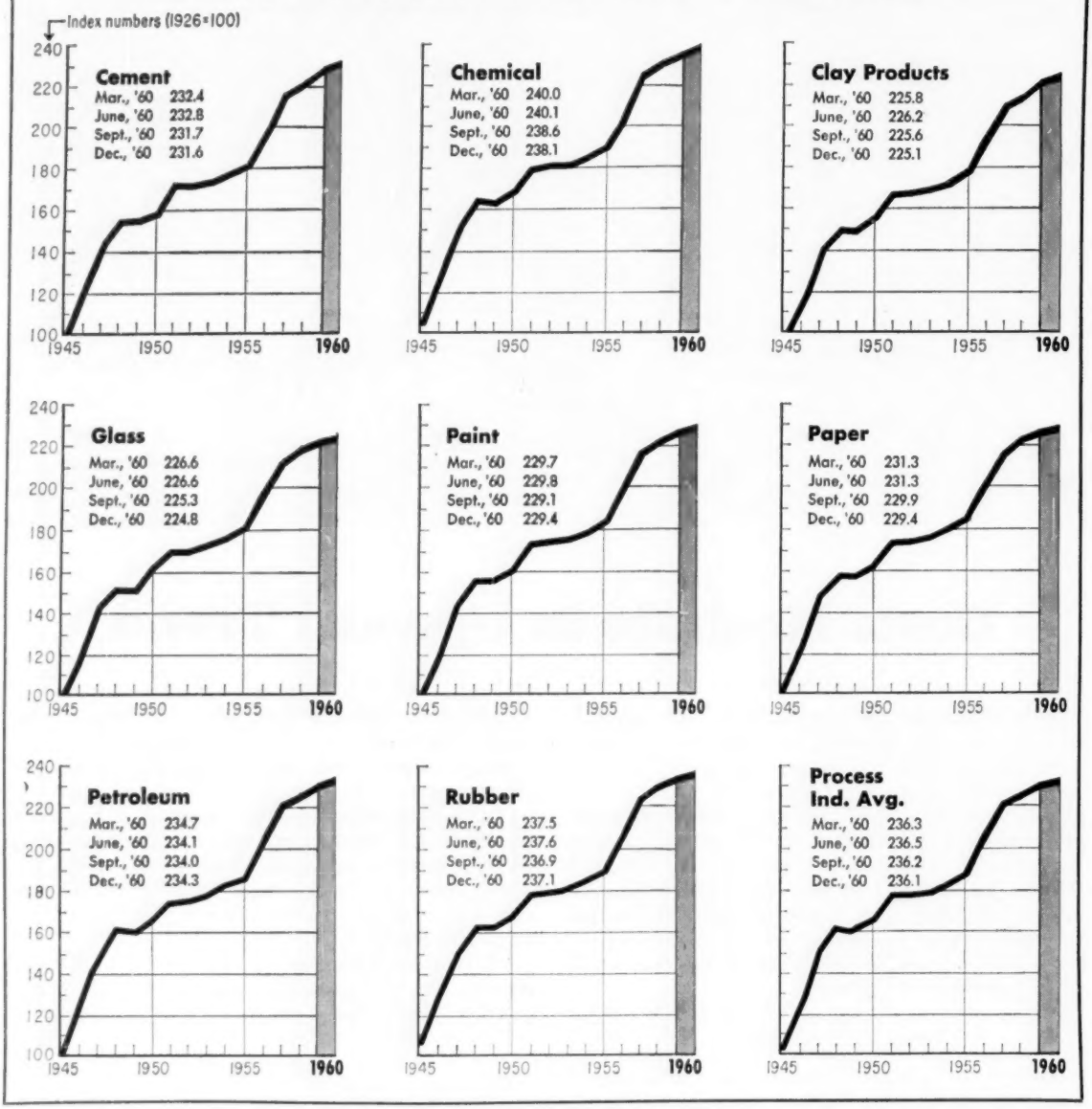
A tabulation in the New Equipment section of every issue in '61 will show the latest revisions for the quarters ending March, June, September, December.

Marshall and Stevens Annual Indexes of Comparative Equipment Costs, 1913 to 1960 (1926=100)

	1913	1916	1918	1920	1922	1924	1926	1928	1930	1932	1934	1936	1937	1938	1939	1940	1941	1942
Average of all....	57.9	62.8	109.7	153.3	85.5	105.3	100.0	96.5	87.0	66.1	74.6	81.6	88.3	84.4	84.3	86.1	92.6	99.6
Process Industries																		
Cement mfg.....	58.0	62.5	109.1	149.2	83.7	104.6	100.0	97.2	87.0	68.9	75.7	82.2	88.8	85.2	84.2	85.1	90.8	97.8
Chemical.....	59.0	63.0	111.9	150.5	82.5	105.6	100.0	96.9	82.0	77.6	75.4	82.5	88.2	84.4	83.4	84.3	93.3	102.0
Clay products....	60.7	65.3	120.0	154.3	82.9	105.7	100.0	97.0	86.1	70.6	75.7	83.2	87.8	83.2	82.3	83.4	87.6	93.1
Glass mfg.....	58.7	63.5	112.1	151.1	83.7	101.9	100.0	95.9	86.6	69.4	75.4	82.6	88.0	83.4	82.5	84.0	88.2	93.7
Paint mfg.....	58.2	62.8	108.0	148.5	84.1	104.0	100.0	94.6	85.7	67.0	74.3	80.4	87.4	83.9	83.4	84.6	90.3	97.3
Paper mfg.....	60.4	63.4	111.8	152.6	83.1	105.6	100.0	96.8	86.5	67.2	75.4	82.7	88.1	84.8	83.7	84.8	90.5	97.5
Petroleum ind....	58.9	64.1	113.0	151.5	82.7	106.0	100.0	97.1	86.2	70.1	76.0	82.6	87.8	83.3	82.1	82.5	88.2	95.2
Rubber ind.....	58.6	63.8	113.8	154.2	88.0	105.9	100.0	91.9	86.2	67.1	75.2	82.2	88.4	85.4	84.9	86.0	94.2	102.7
Related Industries																		
Elec. power equip.	59.1	64.3	114.2	152.2	83.6	106.0	100.0	96.9	86.1	70.1	75.5	82.7	87.9	84.3	83.7	85.3	90.5	96.5
Mining, milling....	56.8	62.9	111.9	149.9	82.8	105.6	100.0	97.2	86.7	67.6	85.6	92.4	97.1	92.6	91.7	92.8	98.5	105.5
Refrigerating.....	59.3	63.2	113.5	153.5	83.9	96.1	100.0	97.0	86.4	70.0	75.4	83.0	87.5	83.0	81.8	82.7	89.0	95.8
Steam power.....	59.1	64.3	114.2	152.2	82.7	106.1	100.0	96.9	86.2	70.1	75.5	82.7	87.0	82.2	81.3	82.4	86.6	92.1

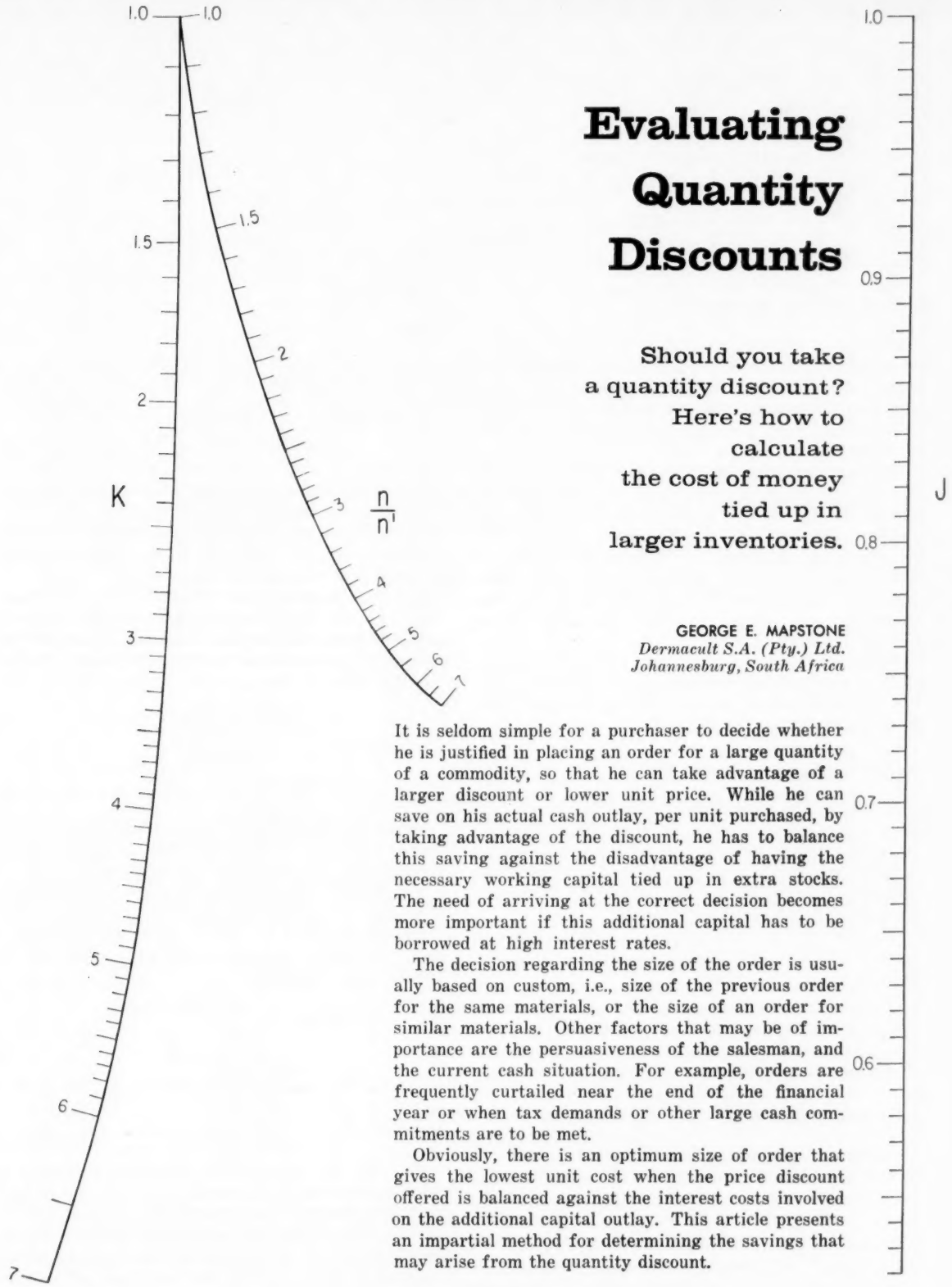
Table continued on following page

In 1960, process equipment costs peaked out in second quarter.



M & S Annual Indexes (continued)

	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Average of all....	100.5	102.4	103.4	123.2	150.6	162.8	161.2	167.9	180.3	180.5	182.5	184.6	190.6	208.8	225.1	231.3	234.9	237.7
Process Industries																		
Cement mfg.....	98.3	98.6	99.4	119.7	144.3	156.5	156.5	161.6	172.7	172.8	174.6	177.6	182.6	199.4	216.4	222.8	228.7	232.1
Chemical.....	103.1	105.6	106.5	126.8	151.5	164.5	164.5	169.6	180.7	181.1	183.1	186.2	191.5	209.1	226.5	232.3	236.5	239.2
Clay products....	93.6	93.9	94.8	115.0	139.8	151.5	151.5	156.6	167.7	167.8	169.5	172.4	177.3	193.8	210.2	216.8	222.2	225.7
Glass mfg.....	94.7	96.5	97.4	117.6	142.3	154.6	154.6	159.7	170.8	171.0	173.0	176.0	180.9	197.5	213.8	219.3	223.2	225.3
Paint mfg.....	98.3	100.1	101.0	121.2	145.9	157.8	157.8	162.9	174.0	174.4	176.3	179.3	184.3	201.2	217.6	223.2	226.9	229.5
Paper mfg.....	98.7	101.3	102.2	122.4	146.9	158.1	158.1	163.2	174.3	174.7	176.6	179.6	184.6	201.5	218.2	223.8	227.8	229.9
Petroleum ind.....	96.7	100.0	100.9	121.6	147.1	160.9	160.9	166.0	177.1	177.6	179.7	182.8	188.0	205.4	222.2	228.0	231.8	234.3
Rubber ind.....	103.7	105.5	106.4	126.6	151.2	163.3	163.3	168.4	179.5	180.0	182.1	185.2	190.5	207.9	224.9	230.8	234.6	237.3
Related Industries																		
Elec. power equip.	97.5	99.3	100.2	122.9	150.0	166.1	166.1	171.2	182.3	182.8	185.0	188.0	193.3	211.0	229.2	235.2	239.0	241.0
Mining, milling....	106.2	107.3	108.2	128.4	152.9	165.2	165.2	170.7	181.4	181.9	184.1	187.1	192.6	210.4	227.9	233.8	237.1	240.6
Refrigerating.....	97.0	100.2	101.7	125.7	163.2	176.6	175.8	185.2	200.1	200.7	202.8	204.8	211.6	234.3	254.2	260.8	265.1	268.2
Steam power.....	92.8	93.9	94.8	116.0	141.7	153.2	153.2	158.4	169.9	170.5	172.6	175.5	180.4	197.0	213.0	218.6	222.9	224.7



$J = \left(1 + \frac{i}{d}\right)^{\frac{-Qd}{R}}$; Correction to present value

$K = \frac{P'Q' + C'}{PQ + C}$; Order cost ratio

$\frac{n}{n'}$; Order size ratio

Evaluating Quantity Discounts

Should you take a quantity discount? Here's how to calculate the cost of money tied up in larger inventories.

GEORGE E. MAPSTONE
Dermacult S.A. (Pty.) Ltd.
Johannesburg, South Africa

It is seldom simple for a purchaser to decide whether he is justified in placing an order for a large quantity of a commodity, so that he can take advantage of a larger discount or lower unit price. While he can save on his actual cash outlay, per unit purchased, by taking advantage of the discount, he has to balance this saving against the disadvantage of having the necessary working capital tied up in extra stocks. The need of arriving at the correct decision becomes more important if this additional capital has to be borrowed at high interest rates.

The decision regarding the size of the order is usually based on custom, i.e., size of the previous order for the same materials, or the size of an order for similar materials. Other factors that may be of importance are the persuasiveness of the salesman, and the current cash situation. For example, orders are frequently curtailed near the end of the financial year or when tax demands or other large cash commitments are to be met.

Obviously, there is an optimum size of order that gives the lowest unit cost when the price discount offered is balanced against the interest costs involved on the additional capital outlay. This article presents an impartial method for determining the savings that may arise from the quantity discount.

Cost of Order

The cost of money borrowed to pay for an order is the interest charged on the loan. If the capital is on hand, the cost is the interest that could be obtained

by employing the cash in making investments or loans.

In order to eliminate variations due to the interest rate, we can base our calculations on the *present value* of the order; this is the amount of money that would have to be invested at the current rate of interest to equal the purchase price at the time of purchase.

Cost of Placing an Order

The cost of placing and paying for an order can be a significant portion of the cost of the material purchased, amounting to $8 per order in many cases. Although this amount may be insignificant with large or infrequent orders, it should not be overlooked with small or frequent orders.

This cost is seldom if ever isolated and is usually absorbed in general office overhead. It is, nevertheless, a cost that is incurred and, as such, it reduces the profits of the company. In a few offices, one may hear the comment, "If they didn't have these orders to handle they would have nothing to do." Such offices are undoubtedly overstaffed, and savings in the form of reduced costs are not welcome. This article is not for this minority of firms.

The composition and amount of the cost of placing and handling each order will not be considered further but will be assumed to be C dollars, incurred effectively on the date of payment of the order.

Additional Costs of Larger Orders

Normally, the main factor in deciding whether to place a larger order is the reduced price. However, the larger orders sometimes involve additional warehousing or storage charges. When incurred, these additional charges should be included in C, the cost of placing and handling the order.

The present value of n successive orders for Q units each is as follows (assuming constant stock usage):

Order	Total Cost†
1st	$PQ + C$
2nd	$(PQ + C)\left(1 + \frac{i}{d}\right)^{-Qd/R} = (PQ + C)J$
3rd	$(PQ + C)\left(1 + \frac{i}{d}\right)^{-2Qd/R} = (PQ + C)J^2$
nth	$(PQ + C)\left(1 + \frac{i}{d}\right)^{(1-n)Qd/R} = (PQ + C)J^{(n-1)}$

Summing gives the total present cost of the nQ units so purchased:

$$T = (PQ + C)\frac{(1 - J^n)}{(1 - J)} \qquad (1)$$

Now, if Q units can be purchased at a price of P/unit while Q' units can be purchased at a price of P'/unit, any saving will be the difference between the present costs of ordering the same total quantity in units of Q and Q', or where:

$$nQ = n'Q' \qquad (2)$$

(n and n' are always integers)

This saving will be given by:

$$S = (PQ + C)\frac{(1 - J^n)}{(1 - J)} - (P'Q' + C)\frac{(1 - J'^{n'})}{(1 - J')} \qquad (3)$$

Now $J = \left(1 + \frac{i}{d}\right)^{-Qd/R}$

and $J' = \left(1 + \frac{i}{d}\right)^{-Q'd/R}$

From Eq. (2)

$Q' = Q^{n/n'}$

whence

$$J' = \left(1 + \frac{i}{d}\right)^{-(Qd/R)(n/n')}$$

i.e., $J' = J^{n/n'}$ (4)

Eliminating J' between Eq. (3) and (4) gives

$$S = \left(\frac{PQ + C}{1 - J} - \frac{P'Q' + C'}{1 - J^{n/n'}}\right)(1 - J^n) \qquad (5)$$

If S is positive, the savings will be made by purchasing the quantity Q' instead of Q on each order. On the other hand, if S is negative, the quantity Q is the more economic order level. In either case, the saving will be the absolute value of S.

If $S = 0$, neither order level shows any advantage over the other. This condition means that the interest rate is such that the interest charges on the additional capital just balance the quantity discount. In this case, Eq. (5) reduces to:

$$\frac{PQ + C}{1 - J} = \frac{P'Q' + C'}{1 - J^{n/n'}} \qquad (6)$$

whence

$$\frac{P'Q' + C'}{PQ + C} = \frac{1 - J^{n/n'}}{1 - J} = K \qquad (7)$$

Solution of Eq. (7) for J, and hence for i, will then give the effective interest rate that will just balance the discount offered on the larger quantity.

The number of orders, n, for the smaller quantity Q will be larger than the number of orders, n', for the larger quantity Q'. Also n and n' will be integral and will usually bear a simple relationship to one another. By writing:

$$J = F^{n'} \qquad (8)$$

Eq. (7) becomes:

$$\frac{1 - F}{1 - F^{n'}} = K \qquad (9)$$

which can be expanded in descending powers of F to give:

$$F^{(n-1)} + F^{(n-2)} + \ldots + F^{n'} + (1 - K)F^{(n'-1)} + (1 - K)F^{(n'-2)} + \ldots + (1 - K)F^2 + (1 - K)F + (1 - K) = 0 \qquad (10)$$

Eq. (10) can be solved for F but the method to be adopted depends on the values of n and n'. In general, the equation is best solved for values of n above three by using Horner's method* to find the root between zero and one. However, since n and n' are integral quantities and usually in simple ratio to one another, the effect of substituting common ratios in Eq. (9) and (10) gives the following special cases:

† See nomenclature table on last page.

* An explanation of Horner's method for solving polynomial equations may be found in many texts, e.g., Sokolnikoff, I. S., and E. S., "Higher Mathematics for Engineers and Physicists," 2nd edition, McGraw-Hill Book Co., 1941.

n	n'	Equation	Eq. No.
2	1	$F = K - 1$	(11)
3	1	$F = -\frac{1}{2} + \frac{1}{2}\sqrt{4K - 3}$	(12)
3	2	$F = \frac{1}{2}(K - 1) + \frac{1}{2}\sqrt{K^2 + 2K - 3}$	(13)
4	1	$F^3 + F^2 + F + (1 - K) = 0$	(14)

Eq. 14 can be solved by the general methods applicable to cubic equations, or by Horner's method.

Example 1

Should an order be placed for 1,000 gross of oil cans at \$12.50/gross or for 500 gross at \$14.50/gross, when the annual requirement is 1,500 gross? The larger order will not affect warehouse costs. Money is worth 8%/yr., compounded monthly.

Then: $Q = 500$; $Q' = 1{,}000$; $P = 14.50$; $P' = 12.50$; $i = 0.08$; $d = 12$, i.e., compounded 12 times a year; and $R = 1{,}500$. Since no data are given for the costs of placing and handling the orders, C and C' are neglected.

We can now calculate the savings that arise from buying 1,000 gross at a time, rather than 500 gross.

From Eq. (2): $500n = 1{,}000n'$

Since n and n' should have the smallest possible integral values in order to simplify the calculations, put $n' = 1$; then $n = 2$. Then:

$$J = \left(1 + \frac{i}{d}\right)^{-Qd/R}$$
$$= (1 + 0.08/12)^{-500(12/1{,}500)}$$
$$= 0.973769$$

From Eq. (5), we have:

$$S = \frac{14.5 \times 500}{1 - 0.973769} - \frac{12.5 \times 1{,}000}{1 - 0.973769^2}(1 - 0.973769^2)$$
$$= \$1{,}826.10$$

That is, the purchase every eight months of 1,000 gross cans, instead of 500 gross each four months at the higher price, will effect a saving of \$1,826.10 each eight months.

In order to calculate the effective interest rate on the extra financial outlay equivalent to this saving, solve Eq. (7) for J and then for i. Since $n = 2$ and $n' = 1$, Eq. (11) can be applied.

$$F = J = K - 1$$
$$K = \frac{12.5 \times 1{,}000}{14.5 \times 500}$$
$$= 1.724$$
$$J = 0.724$$
$$= \left(1 + \frac{i}{12}\right)^{-4}$$
$$i = 1.044 \text{ or } 104.4\%$$

The saving possible from placing an order for the larger quantity, therefore, involves a saving equivalent to an annual interest of 104.4% on the additional outlay. In other words, if the cash must be borrowed, any interest rate less than 104.4%, compounded monthly, is an economic proposition in this case.

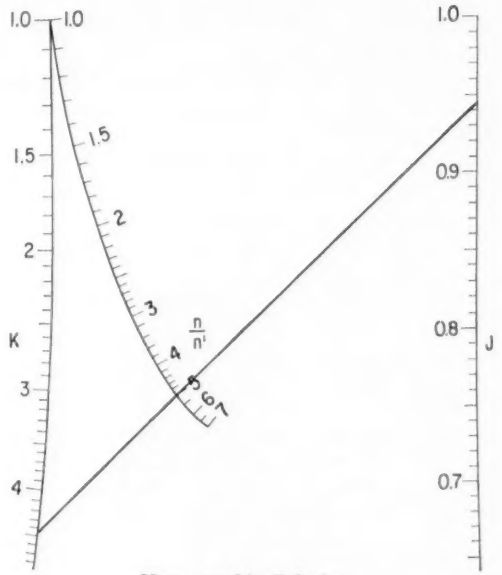
The above example is a relatively simple though common one and can be checked as follows: expenditure on 1,000 gross at \$12.50/gross is \$12,500; expenditure on 500 gross at \$14.50/gross is \$7,250; additional expenditure on larger order is \$5,250. The present value of the \$7,250 that will need to be spent in four months time, if the smaller order is placed with money worth 8% compounded monthly, is:

$$\$7{,}250\left(1 + \frac{0.08}{12}\right)^{-4} = \$7{,}076.10$$

but the additional amount actually spent on the larger order is \$5,250, hence the saving of \$1,826.10.

This saving is due to the additional investment made at the time of the first purchase, and four months prior to the time the second purchase would have had

Solution of Eq. (7) for Example 3



Nomographic Solution

In order to reduce the labor involved in solving Eq. (7) by Horner's method, the accompanying nomograph was designed. Since the design required some simplifying assumptions, it is not quite so accurate for the higher values of K and n/n' as the mathematical method, but is sufficiently accurate for most purposes. This is shown by the value of J calculated in the worked examples as compared with the values obtained from the chart:

Example No.	K	n/n'	J (Calc.)	J (Chart)
1	1.724	2.0	0.724	0.724
2	4.76	5.0	0.985	0.980

Attempts to design an extension to the chart to allow the direct solution of i from J and Qd/R were unsuccessful. However, since the methods of calculating present values are well known and straightforward, it is felt that the single chart presented on the first page of this article should be adequate for most purposes.

to have been made. The effective interest rate can then be computed as follows:

$$7{,}250 = 5{,}250\left(1 + \frac{i}{12}\right)^4$$

$$i = 1.044 \text{ or } 104.4\%$$

This check confirms the applicability of the method in the frequently occurring simple case where the order size was doubled to take advantage of the quantity discount.

Example 2

An additive is used at the rate of 350 gal./mo. and is purchased in drums containing 45 gal. The cost is \$5.50/gal., in lots of 10 to 49 drums and \$5.25/gal., in lots of 50 or more drums. The cost of placing, handling and paying for an order is \$8, and money is worth 6¾%, compounded monthly. Storage is adequate to handle a 50-drum order without incurring extra expense. Is there any advantage in purchasing 50 rather than 10 drums and, if so, what is the extent of the advantage?

Here: $C = 8$; $d = 12$; $i = 0.0675$; $P = 5.50$; $P' = 5.25$; $Q = 450$; $Q' = 5 \times 450 = 2{,}250$; and $R = 350 \times 12 = 4{,}200$.

Since the alternative orders are for 10 or 50 drums of additive, we can write $n = 5$ and $n' = 1$. Then:

$$J = \left(1 + \frac{0.0675}{12}\right)^{-450(12/2{,}250)}$$

$$= 0.986622$$

The saving that can be realized is then given by Eq. (5) as:

$$S = \frac{5.50 \times 450 + 8}{1 - 0.986622} - \frac{5.28 \times 2{,}250 + 8}{1 - 0.986622^5}(1 - 0.986622^5)$$

$$= \$26.75$$

In this case, the order for the larger quantity is favored by the narrow margin of only \$26.75 on an expenditure of \$11,812.50. It is therefore an advantage to know the effective interest rate of this saving. This will be obtained by the solution of Eq. (10) after substituting the values $n = 5$ and $n' = 1$ to give:

$$J^4 + J^3 + J^2 + J + (1 - K) = 0$$

$$K + \frac{5.25 \times 2{,}250 + 8}{5.50 \times 450 + 8}$$

$$= 4.76057$$

$$\text{i.e., } J^4 + J^3 + J^2 + J - 3.76057 = 0$$

Solution by Horner's method gives the root between zero and one as $J = 0.98502$, whence $i = 0.07568$, or approximately 7.6%. Consequently, should the interest rate increase from 6¾% to slightly over 7½%, it would be advisable to order the smaller lots of 10 drums each.

Example 3

A chemical intermediate is purchased in 200-lb. lots at \$15.90/lb. Orders for 1,000 lb. cost \$14.30/lb. What annual consumption would justify the larger order? The cost of placing and handling an order is estimated to be \$9 and the cost of money is 12%, compounded monthly. Then: $P = 1{,}000$; $P' = 200$; $C = C' = 9$; $i = 12$; $Q = 14.30$; $Q' = 15.90$; $n/n' = 5$; and $d = 12$

$$K = \frac{14.30 \times 1{,}000 + 9}{15.90 \times 200 + 9} = 4.487$$

Using the nomograph with this value of K, and $n/n' = 5$, gives $J = 0.944$. Substituting the various values in the expression for J yields:

$$0.944 = 1.01^{-12{,}000/R}$$

$$R = 2{,}064$$

Therefore, it is more economical to order 1,000 lb. at a time, if the annual consumption exceeds 2,064 lb.

Nomenclature

C	Cost of placing and handling an order.
d	Number of interest determinations per year.
F'	$(J)^{1/m'}$ [see Eq. (8)].
i	Interest rate as a decimal (6% = 0.06).
J	$(1 + i/d)^{-Qd/R}$, correction from future to present value.
K	$\frac{P'Q' + C'}{PQ + C}$, ratio of costs of orders.
m	Number of periods of interest determinations between consecutive orders.
n	Number of orders.
P	Price per unit purchased.
Q	Number of units per order.
R	Rate of usage, units/yr.
S	Savings.
T	Total cost of a series of orders.

Units with primes (′) refer to alternative orders.

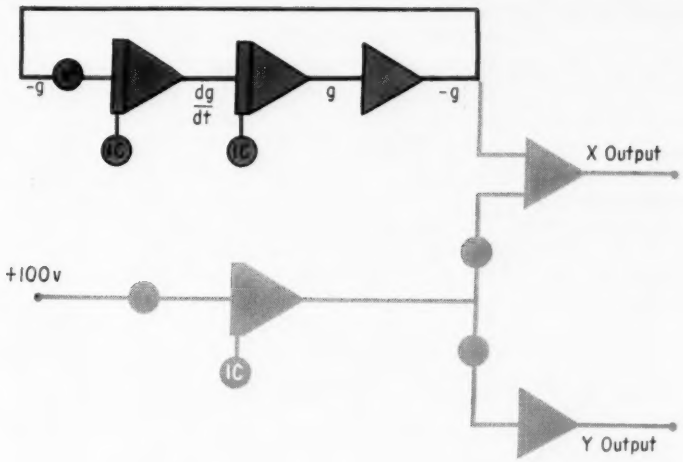
Meet the Author

GEORGE E. MAPSTONE *is chief chemist and factory manager of Dermacult S.A. (Pty.) Ltd., Johannesburg, South Africa. He was born and educated in New Zealand, receiving his B.Sc. and M.Sc. at the University of Canterbury. He later obtained his Ph.D. from the University of South Africa where he recently received the degree of Bachelor of Commerce.*

Although he is now in the cosmetics field, most of his previous experience has been in the manufacture of gasoline from shale oil, both in Australia and South Africa.

Dr. Mapstone is a Fellow of the Royal Economic Society and a member of many societies concerned with chemistry, chemical engineering, petroleum and fuels.

Analog computation is generally thought of as a way for solving ordinary differential equations. But it is also possible to handle partial differential equations with analog computers. Here, two methods are described for developing chemical engineering problems that require use of these equations, with a numerical example.



Analog Solves Partial Differentials

L. W. ZABEL and S. W. McKIBBINS, *Kimberly-Clark Corp., Neenah, Wis.*

It's frequently necessary to solve partial differential equations in many areas of chemical engineering—in heat and mass transfer, fluid mechanics, and most unsteady-state or transient process problems.

These equations are required to describe phenomena of interest whenever more than one independent variable is present, such as two or more physical dimensions, or in any problem involving time as well as distance. With electronic analog computing equipment, solutions to many of these equations can be quickly and economically obtained.

Since electronic analog computers can integrate with respect to only one variable, they are not capable of solving partial differential equations directly. Where two independent variables are involved, computer solution is quite straightforward, and a solution is generally possible. When three independent variables are concerned, however, the method of solution becomes quite complex, and requires use of much computing equipment. Solutions are, therefore, uncommon, and when more than three independent variables are involved, a solution is rarely attempted.

In all cases, it is necessary first to convert the given equation into ordinary differential equations, which the computer can solve, and then to combine these results properly to obtain the desired solution. The two common techniques used to perform these transformations are (1) separation of variables and (2) the finite-difference technique.

Where the variable are separable, the partial differential equation may be separated into two or more ordinary differential equations. Depending on the order of these equations, each may have initial conditions and boundary conditions to be satisfied. These restraints are often satisfied only for certain discrete values ("characteristic values" or "eigenvalues") of the equation parameters.

Use Analog for Eigenvalues

The analog computer can be a useful, time-saving tool in determining these eigenvalues and, hence, the equation solutions. This method of solution is restricted, however, to linear, homogeneous equations. Consequently, although only a moderate amount of computing equipment is normally required and the solutions are usually quite accurate, the method is rarely used.

Analog computers cannot be programmed directly to arrive at a predetermined point at some predetermined future time. The problem of determining eigenvalues, then, becomes one of trial-and-error. Where the ordinary differential equations are second-order, we have one initial condition and one final condition. It is usually a simple matter to vary the single parameter to reach the final condition.

Third-order equations, which have one initial and two final conditions, require that two parameters be adjusted. It's usually possible to find a two-valued convergence scheme and arrive at the proper final values. Where three or more parameters must be adjusted, however, the problem is usually not attempted.

This eigenvalue method will be illustrated with a steady-state, two-dimensional heat flow problem.[5]

Assume a semi-infinite plate that has thickness L in the x direction, and extends indefinitely in the positive y direction. The faces, $x = 0$ and $x = L$, are maintained at the constant temperature $T = 0$. The temperature at the base, $y = 0$, is maintained at a temperature corresponding to some function of x, $f(x)$.

The temperature is independent of the z direction, so the equation describing the temperature of any point within the plate is the two-dimensional LaPlace equation,

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0 \qquad (1)$$

the solution of which requires the following conditions to be satisfied:

At $x = 0$, $T = 0$ At $y = \infty$, $T = 0$
At $x = L$, $T = 0$ At $y = 0$, $T = f(x)$

Following the classical mathematical approach, we assume that the variables are separable, that the solution may be written as the product of two functions, each containing only one independent variable:

$$T = g(x)h(y) \qquad (2)$$

This solution may then be substituted into Eq. (1) to obtain the following expression, in which the partial derivatives have been replaced by ordinary derivatives:

$$(1/g)d^2g/dx^2 = -(1/h)d^2h/dy^2 \qquad (3)$$

Since x and y are both independent variables, Eq. (3) can be true only if each side of the equation is equal to some constant, e.g., $-k^2$. Therefore, the problem may be resolved by solving these two ordinary differential equations:

$$(1/g)d^2g/dx^2 = -k^2 \qquad (4)$$
$$-(1/h)d^2h/dy^2 = -k^2 \qquad (5)$$

Since analog computers can integrate only with respect to time, the computer equation corresponding to Eq. (4) becomes

$$d^2g/dt^2 = -k^2g \qquad (6)$$

The computer circuit required for solving this equation is that loop shown in color on p. 121.

The initial conditions require that $T = 0$ at $x = 0$. Thus, $g(x)$ must equal zero at $T = 0$, and the initial condition on the second integrating amplifier must be zero. The initial condition on the first integrator depends on $f(x)$ and the value of the parameter, $-k^2$. This parameter, which is set on the indicated potentiometer, must be determined such that $T = 0$ at $x = L$. To determine the appropriate value or values of $-k^2$, we must first scale t. For example, we can say that one second of computer time equals one inch in the x direction. This is done on the computer by adjusting the gains of the integrating amplifiers.

Upon running the computer with this circuit, we find that there are many values of $-k^2$ (i.e., many potentiometer settings) that satisfy the equation. In all cases, the solution is a sine curve, with the frequency determined by the value of k. (A mathematical solution indicates that $k = n\pi/L$, where n is an integer.) Since Eq. (1) is linear, the sum of any or all solutions will also be a solution. Therefore, $f(x)$ can be any function that satisfies the boundary conditions and can be described by a Fourier series of sines.

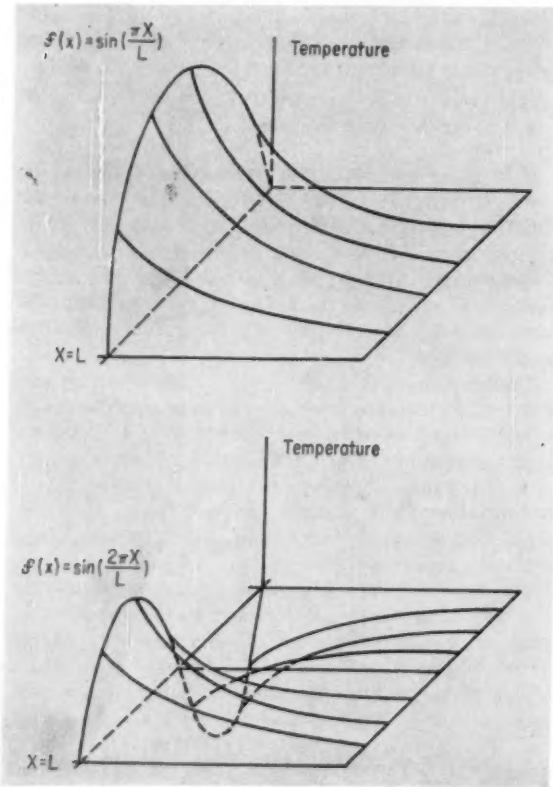
Now turn to Eq. (5). The computer equation becomes $d^2h/dt^2 = hk^2$, and the computer circuit is similar to the colored part of the diagram on p. 121, except that there is no final sign-changing amplifier.

In this case, y must be scaled to t. Here, we have used the same scaling as for x, but this is not required. The value of k, however, must be the same value determined by the solution of Eq. (4). The boundary conditions to be satisfied by this equation require that at $t = 0$ (i.e., $y = 0$), $h(y)$ must have the value indicated by $f(x)$. This restriction is met by properly setting the initial condition on the second integrator.

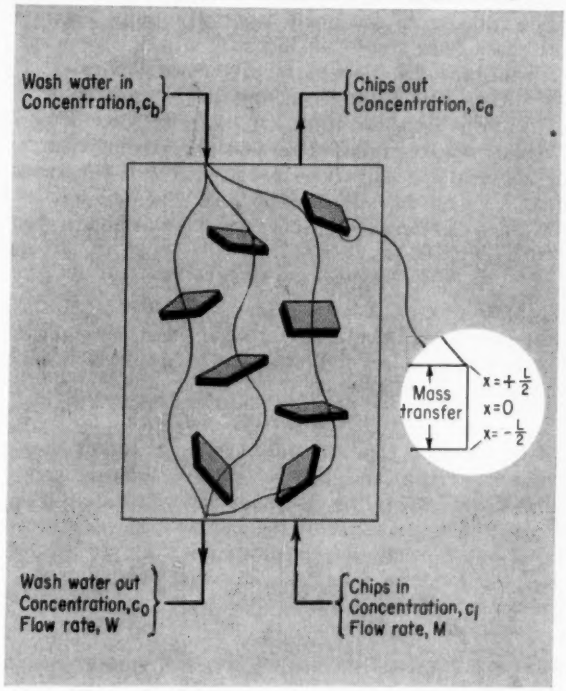
The second boundary condition to be satisfied requires that $h(y) = 0$ when $t = \infty$. This restriction is met by performing multiple computer runs with adjustment of the initial values of $-dh/dt$. When this condition is realized, the solution to the given partial differential equation has been obtained, and the temperature at any point in the plate may be determined.

Fig. 1 shows two possible solutions to Eq. (1). The upper figure is the solution for $n = 1$, so that $f(x) = \sin(\pi x/L)$. The lower figure is the solution

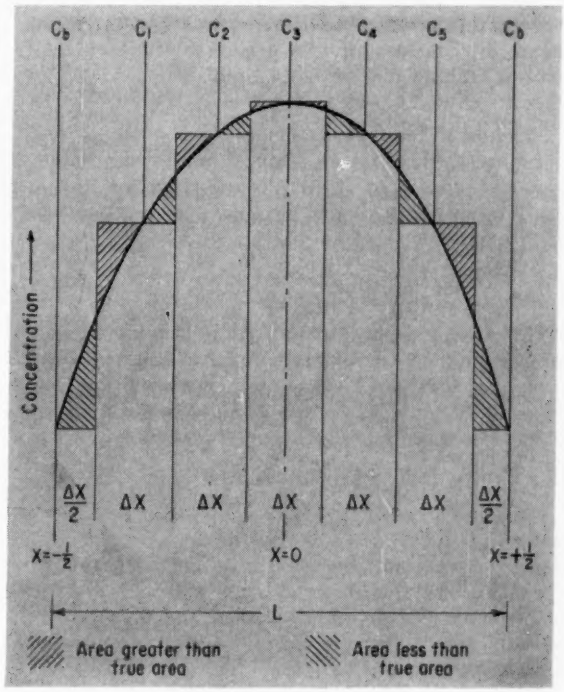
Two solutions to LaPlace equation.—Fig. 1



Try extraction problem on analog.—Fig. 2



Divide chip into seven increments.—Fig. 3



for $n = 2$, so that $f(x) = \sin(2\pi x/L)$. As indicated previously, the sum of these and similar solutions would also constitute solutions dependent on the definition of $f(x)$.

Fig. 1 incorporates an interesting technique available in analog solutions for providing an isometric drawing of the temperature surface directly. The x axis was obtained by adding a ramp function to the sine function during plotting. The computer circuit is the full diagram on p. 121.

Finite-Difference Technique

The finite-difference technique is more widely used than that of the separation of variables, and its application is not restricted to linear equations.

In this approach, one of the independent variables may be considered continuously, while the others are divided into a number of discrete increments just as they would be in a numerical integration. The partial differential equation may then be rewritten for each of these increments as an ordinary differential equation in which the variable treated incrementally does not appear. The given partial differential equation is, therefore, replaced by a number of ordinary differential equations that must be solved simultaneously.

The derivative involving those independent variables that are treated incrementally must first be replaced by finite-difference quotients, which approximate the actual derivative. There are various types of finite-difference quotients that might be used, and the choice depends to a large extent on the particular problem. The appropriate approximation is most easily found by considering an expansion in terms of a Taylor series. [2,3]

If c is a single-valued function of x, and is continuous in the interval Δx from the nth to the $(n + 1)$th boundary, a Taylor series expansion about the point n (for fixed values of any other variables of which c is a function) is:

$$c_{n+1} = c_n + \Delta x \frac{\partial c_n}{\partial x} + \frac{\Delta x^2}{2!} \frac{\partial^2 c_n}{\partial x^2} + \frac{\Delta x^3}{3!} \frac{\partial^3 c_n}{\partial x^3} + \ldots \quad (7)$$

From this series expansion, backward, forward and central difference quotients may be developed, which possess various degrees of approximation. In addition, an estimate of the errors involved in the use of each is readily available. As an example, for a first approximation to the first derivative, the forward-difference quotient may be obtained from this series by neglecting all terms in it containing powers of x^2 or higher.

$$\frac{\partial c}{\partial x} \approx \frac{c_{n-1} - c_n}{\Delta x} \quad (8)$$

An estimate of the error inherent in the use of this approximation is found from the first term neglected in the series, that is,

$$-\frac{\Delta x}{2} \frac{\partial^2 c}{\partial x^2}$$

The error is proportional to the size of the increment.

Similarly, for a first approximation to the second derivative, a central-difference quotient may be obtained by considering two series expansions about point n. Taking one series to point $(n - 1)$ and the other to $(n + 1)$, and adding, results in

$$\frac{\partial^2 c}{\partial x^2} \approx \frac{c_{n+1} - 2c_n - c_{n-1}}{\Delta x^2} \qquad (9)$$

The first error term associated with this approximation is proportional to the square of the size of the increment.

$$-\frac{\Delta x^2}{12}\frac{\partial^4 c}{\partial x^4}$$

This approach may be similarly used to develop difference quotient approximations for any partial derivative. In addition, higher-order approximations may be made that involve the use of more reference points and that more closely approach the true derivative.[2,3]

Use Finite Difference in Extraction

Consider an extraction tower in which material is being removed from thin chips by a countercurrently moving stream of wash water. Assume that the rate of removal of this material from the chip is a diffusion-controlled process, and that the chips are sufficiently thin to assure mass transfer in only that direction. Assume, too, that the operation is performed isothermally, that the diffusion coefficient remains constant and that there is no resistance to mass transfer in the liquid layer adjoining the chip surfaces. This process is shown in Fig. 2. We want to determine the effect of relative mass flow rates of the two streams, and the washing time, on the recovery of material from the chips.

Under the restraints described, the rate of change of material concentration as a function of time and distance may be described by Fick's second law of diffusion. In terms of dimensionless variables, this may be written as:

$$\partial C/\partial \theta = \partial^2 C/\partial X^2 \qquad (10)$$

where $C = c/c_i$, $X = x/L$, and $\theta = Dt/L^2$. If the concentration of the material is uniform throughout the chip as it enters the tower, the appropriate initial condition is, when $\theta = 0$,

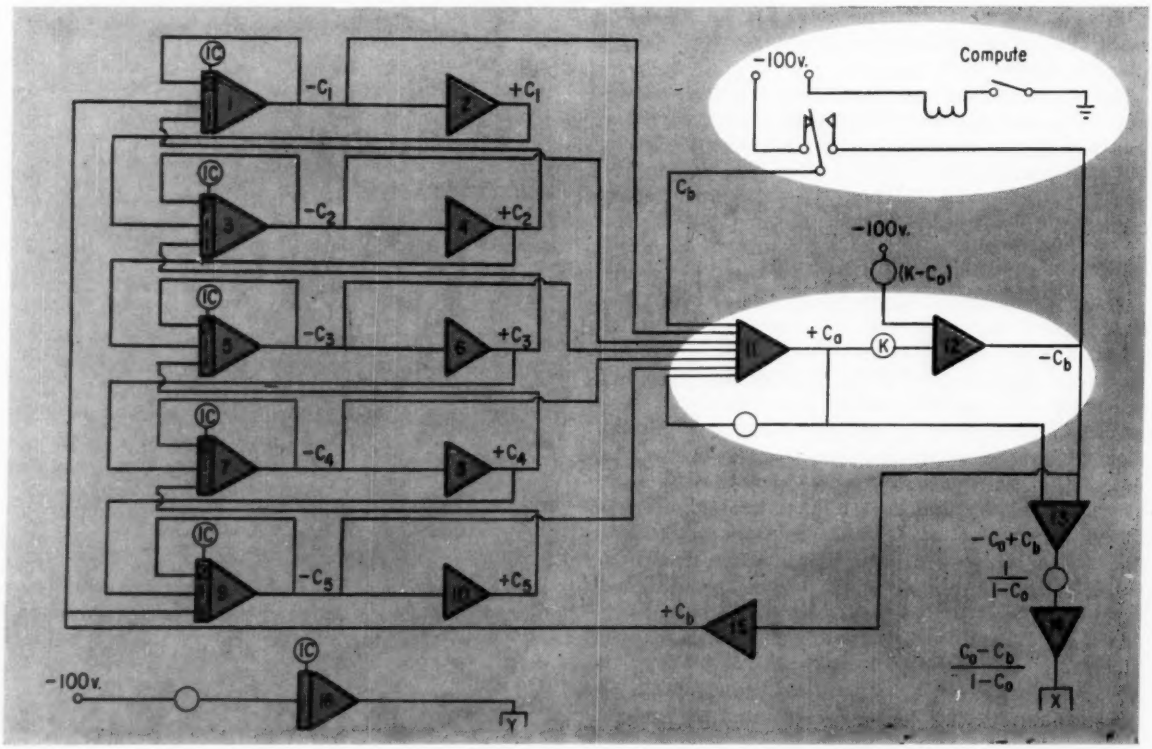
$$C = 1 \text{ for } -1/2 \leqq X \leqq +1/2$$

The boundary conditions are arrived at by considering a material balance between the average concentration of material in the chip and the wash water. The amount of material lost by the chip as it moves up the tower must equal the amount gained by the water over the same height. This material balance is expressed as follows:

$$M(c_i - c_a) = W(c_o - c_b)$$

Since the diffusion occurs along the x direction, where the chip thickness is L, and both faces are at the same

Analog computer finds answer to extraction problem with this wiring circuit.—Fig. 4



concentration (which is also the concentration of the wash water at that height), the boundary conditions become, at $X = \pm\frac{1}{2}$,

$$C_b = KC_a - (K - C_a)$$

where $K = M/W = (C_a - C_b)/(1 - C_a)$.

To solve Eq. (10) on an analog computer by the technique of finite differences, one of the variables must first be divided into a number of discrete increments. For this example, the solution is expedited by treating θ continuously, and dividing the X dimension incrementally. Fig. 3 is a schematic of the edge of one of the chips, which shows the thickness divided into five increments of ΔX widths and two of $\Delta X/2$ width.

Eq. (10) is written individually for each of these increments, thus eliminating X as a variable and giving an ordinary differential equation in the variables C and θ. In each of these increments, then, the concentration varies only as a function of time, and is constant across the increment in the x direction. The second derivative, indicated in the right-hand side of Eq. (10), may be replaced by a finite-difference approximation of the type in Eq. (9). The resulting equation for each full increment is

$$\frac{dC_n}{d\theta} = \frac{C_{n-1} - 2C_n + C_{n+1}}{\Delta X^2} \qquad (11)$$

This equation doesn't apply, however, to the two increments of $\Delta X/2$ width that represent the concentration at the faces of the chip and hence are determined by the boundary conditions.

Wiring the Computer Circuit

Eq. (11) is the basis for the computer wiring diagram shown in Fig. 4. Since the x dimension was divided into five increments, Eq. (11) must be set up five times. The wiring diagram indicates this with five integrator-sign changer sets in parallel (amplifiers number 1-10). The outputs of each set are equal in magnitude but of opposite sign, and represent the solution to Eq. (11) for that particular increment. The same initial conditions are applied to each integrator. As is required by Eq. (11), the input to the nth integrator is composed of the outputs from the $(n - 1)$ and $(n + 1)$ integrator.

Note that the two outside increments require the boundary condition as one of their inputs. There is no need to feed in a value for the width of the increment, ΔX^2, since this is constant, determined by the number of increments used.

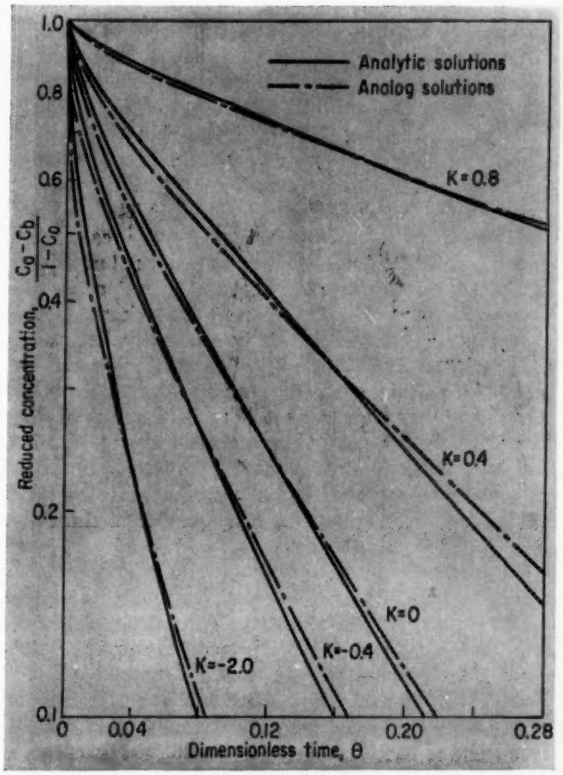
What is really of interest in the solution of this problem is the rate of change of the average concentration as a function of time. As indicated in Fig. 3, the average concentration is equal to the area under the curve divided by the width of the chip. This area may be approximated as shown by taking the sum of the rectangular increments. This is done on the computer, as indicated in Fig. 4, by adding the outputs of the five integrators into one summing amplifier (number 11).

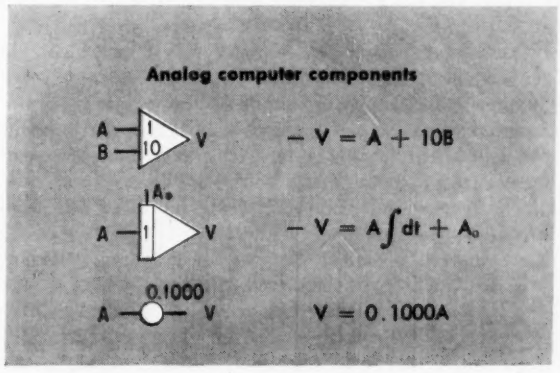
Note that the two half-increments shown in Fig. 3 are included in the sum by adding in the value of the boundary condition once. The required division of this sum by the width of the chip was obtained with a potentiometer in the feedback line around amplifier 11. This potentiometer setting was made at the start of each run by adjusting it until the output of the amplifier equaled unity, required by initial condition.

Two Interesting Points

The development of the circuitry for the boundary-value concentrations required an interesting feedback mechanism. It will be noted from the boundary-value equation that the concentration at the boundary is

Compare the answer with analysis.—Fig. 5





dependent on the value of the average concentration at that same time. The development of the boundary value, therefore, starts with the average concentration, as shown in Fig. 4. This is multiplied by the constant K, which is set on a potentiometer, and then entered into summing amplifier 12, along with the negative value of the constant $(K - C_o)$. Output of this amplifier is therefore the value of the concentration at the boundary.

Another interesting aspect of this circuit concerns the starting switch. Before the computation begins, the value of the concentration at the boundary must be constant and equal to unity, but immediately after the computation begins, the boundary value must vary as required by the problem. The two positions of the computing switch satisfy these restrictions.

The remainder of the circuit was added to provide for the plotting of a reduced concentration. The values of the average concentration and that at the boundary were combined through summing amplifiers 13 and 14 to obtain the reduced grouping, $(C_a - C_b)/(1 - C_o)$. This was then fed through the appropriate time-scaling circuit into an x-y plotter to obtain graphical plots of the results.

Once this wiring diagram is completed, a vast amount of data can be obtained quite easily and quickly. Merely by changing several potentiometer settings, a wide range of inlet and outlet concentrations and mass flow rate ratios (K values) can be investigated. Moreover, if the concentration at any point within the chip is also of interest, its value can easily be plotted by measuring the output from the appropriate integrator (numbers 1-5). Several solutions for the reduced average concentration are plotted in Fig. 5. The plus values of K represent countercurrent flow and the negative values cocurrent flow. The value of $K = 0$ represents a constant boundary condition, or no relative flow.

An estimate of the absolute accuracy of these solutions can be made by comparing them with the analytical solution of Eq. (5). Riese[4] developed this solution for the authors and such a comparison can be made from Fig. 5, where both types of solutions are shown. At all values of K, the analog solution is somewhat lower for small values of θ and somewhat higher for large values of θ. The error involved in the use of these analog solutions depends, therefore, on the area of interest. In the curves shown in Fig. 5, the deviations are all less than 8%, and in most cases closer to 1-2%. In most finite-difference solutions, this error can be reduced even further, simply by considering a large number of smaller increments. The error term associated with Eq. (9) indicates that if the size of the increment is cut in half, the error involved will be reduced approximately four times.

There is a limit, however, to the number of increments that may be used. Although the error is reduced mathematically as the number of increments is increased, the errors introduced into the solution by the computer circuits increases correspondingly, so that at some point the solution becomes less accurate. The accuracy of the computer circuits is limited by the tolerances of the electrical components and the operator's ability to make component settings. This is especially true in problems of the type considered in this example, where a symmetrical distribution exists and random errors may accumulate.

Why Analog Computer Use is Advantageous

The example given above, concerning the countercurrent extraction of a soluble material from thin chips, provides an interesting evaluation of an analog computer solution for a partial differential equation. Since an analytical solution was also obtained, a direct comparison of the results and the necessary effort to obtain them is possible.

The most difficult factor to evaluate economically is the time required to solve a differential equation analytically. In this particular case, a high degree of mathematical skill was required, and one or two man-days were spent in developing the solution. Solution for the average concentration as a function of time was described in terms of an infinite series, the roots of which are obtained from a particular transcendental equation.

Having the solution itself was of little value until it had been numerically evaluated. Tabulations or curves of this solution were not previously available, so that it was necessary to write a digital computer program that would evaluate this solution at discrete points. Writing of the original program, and its subsequent "debugging," required several additional days. The computation itself, of course, required only a few hours, but several more hours were then required to present the data graphically.

The solution on the analog computer, however, was somewhat more straightforward. Fewer distinct steps were required. Generally, setting up the wiring diagram and debugging the circuits constitute the entire problem. Here, where several unusual problems were encountered because of the nature of the boundary conditions, five or six man-days were required. Once the circuitry was completed, however, solutions were obtained for a wide range of several parameters within an hour. These solutions were obtained in graphical form, too, ready for use. Often another advantage is cheaper capital cost for the analog equipment.

ACKNOWLEDGMENTS

The authors are indebted to W. A. Dickens and K. I. Mummé for their helpful suggestions in preparing this manuscript.

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BRIEFS

oxalic acid
phosphoric anhydride
chlorine chemistry

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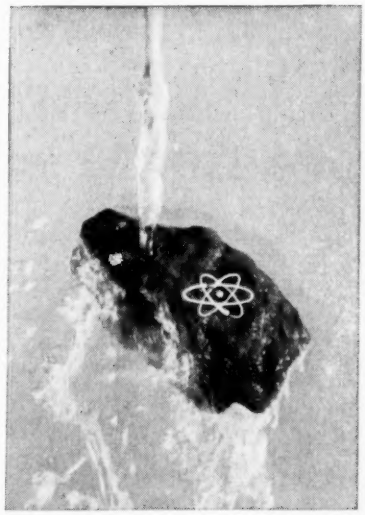

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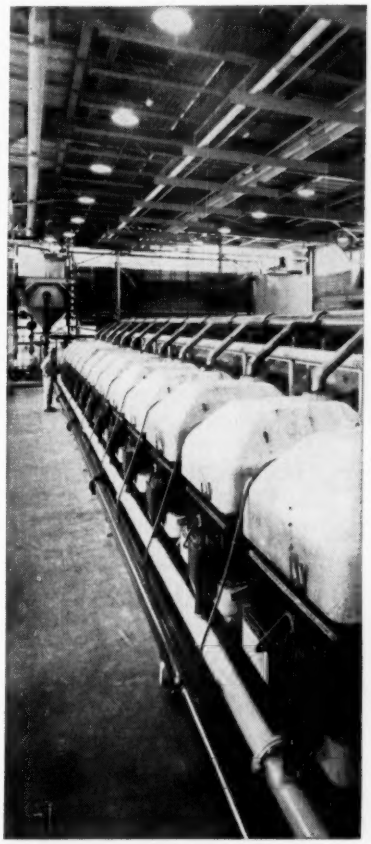

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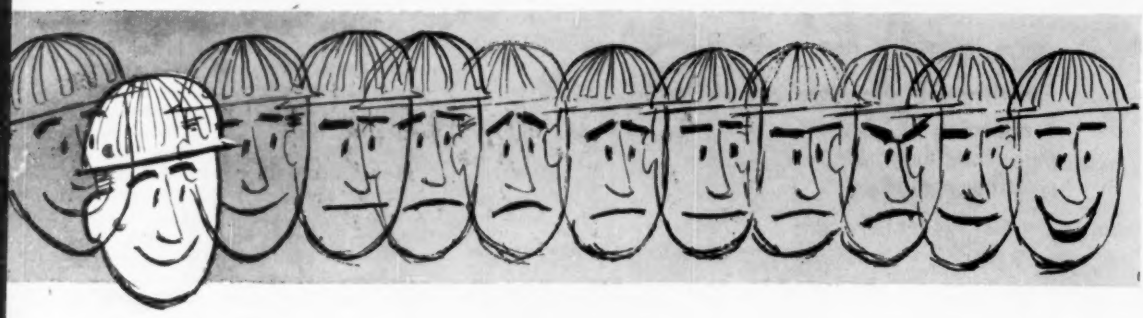

How to Improve the Meetings You Run

Dynamic leadership will be the difference between success and failure of your next meeting.

LYNN SURLES, *Lynn Surles & Associates*
W. A. STANBURY, JR., *Textile World*

Ask yourself—and answer—the following questions:

- In the course of your regular work, how many meetings—group discussions, conferences and the like—did you attend last month?
- What was the total number of man-hours given to these meetings by all those attending?
- How many of these man-hours were wasted in aimless talk about trifles, side issues and personalities?
- How much money did these wasted hours cost your organization last month?

Coming up with this last figure probably gives you a rude jolt.

Now think back and analyze what went on at these meetings. If they were like all too many, you can charge up most of those wasted hours to chairmen, conference leaders and supervisors who don't know how to keep a meeting moving towards its objective. If this is your weakness—if some part of those wasted dollars can be charged up to you—read on.

The conference or discussion leader is like the conductor of a symphony orchestra. The conductor has a plan—the musical score that lies on the music stand in front of him. He plays one instrument off against the other, keeps them all under control, blends their voices to achieve his harmonies. He reconciles the conflicting musical themes that run through the score, thus comes at last to the end of the composition with a feeling of achievement and completion.

Like the orchestra conductor, the leader of a meeting must manage all the various people who make up the group. His skill shows up in how well he can do the five following jobs:

1. *Stimulate Ideas*—You know in advance what the subject of the meeting will be. With the subject in mind, review the skills and experience of each person who will attend, in the light of what he can contribute to the discussion. Then, as some one aspect of the subject comes up, invite the comment of the man whose skill and experience qualify him to talk most meaningfully about that aspect. If you show your need for him and your confidence in him this way, he'll give his best to the discussion at hand.

Another way to stimulate ideas: as leader, watch for ways to make provocative statements or ask provocative questions as the meeting moves along. You might even prepare some ahead of time. Suppose, for instance, you've got a meeting of foremen coming up. The subject for discussion: absenteeism. You might throw out this question at an appropriate place in the discussion: "They tell me the rayon plant across town has no absentee problem at all. How do you account for that?" Or "This is a brand-new problem for us. We didn't have it six months ago. What happened?"

2. *Inspire Teamwork* — Sometimes this isn't easy. People like to argue—and argument, in a sense, is conflict. People get angry. Or they reveal their selfish, personal motives. Or they get defensive about their views. Or they bring personalities into the discussion.

Usually, though, you can create a teamwork approach in spite of situations like these.

First step is to set the stage properly—when you open the meeting. Take that meeting on absenteeism up above. You could start it off this way:

"This meeting is about absenteeism. Every week, it's getting to be a bigger problem for us. As an offhand guess, I'd say it's now cutting our production down by about 10%. Our machine operators are giving us the most trouble. That's Shelton's department. But Shelton's trouble hits us all. It cuts down on

• This article is based on Chapter 13 of "The Art of Persuasive Talking," McGraw-Hill Book Co., New York, 1960. Other topics in the book include how to overcome obstacles to running a meeting, how to argue convincingly—and prove your point—and how to talk well when you have no time to prepare.

Foxboro pH Dynalog Recorder has an input impedance of 80,000 megohms — eliminates the need for intermediate amplification. Span is adjustable from 2-12 pH; zero, from 0-12 pH.

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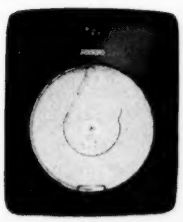

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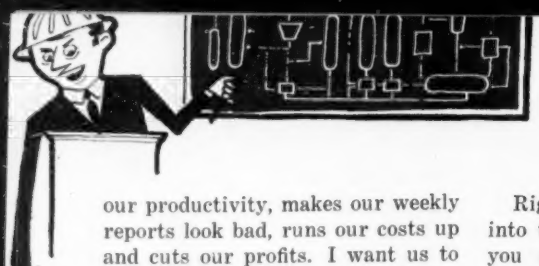

our productivity, makes our weekly reports look bad, runs our costs up and cuts our profits. I want us to try to find an answer for Shelton's problem. If we do that, we'll be solving some of our own problems, too."

What's achieved by this kind of stage setting? Just this: you show that the meeting has a constructive purpose, that the subject has a bearing on every member of the group, and every member has a stake in what's said and done about it. With this approach, participants are less likely to attack Shelton for his shortcomings, more likely to help him (and the company) find an answer to the problem.

Second step in inspiring teamwork is to probe for the constructive element in every nonconstructive comment, however ill-tempered, ill-conceived, far afield or poorly stated it may be. Often this will take some doing — even some stretching of your imagination. Once you find that constructive element, announce it to the group —but attribute it to the speaker.

Go back to Shelton's problem—absenteesim. Crawford, assembly-line foreman, is angry because absenteeism in Shelton's department last week caused three assembly-line workers to stand idle for two half-days. Crawford takes out after Shelton: "I can't see any excuse for running a department as loosely as you run yours. I don't think you can stand up to your people. What you need is the guts to fire a couple of them."

Right there is where you come into the act. "Thanks, Crawford," you say. "I think you've added something to the discussion. We probably ought to take a new look at discipline throughout the plant. Maybe we're all too lax. Would you, Shelton and Rodinski form yourselves into a task force, study the problem and bring in some recommendations a week from now?"

This gambit will nudge Crawford off his selfish center—shift his attack from Shelton to the problem. You've probably seen skillful leaders do the same thing time after time in meetings. The more such a person as Crawford argues, the more the leader meets him with appreciation for his "contribution" to the discussion. At first the man is confused. But the strategy swings him around and he soon comes to realize that—in spite of himself—he's not really engaged in argument but is contributing to the answer for a problem. Gradually, as the leader reveals this contribution, the chip slips off his shoulder and he begins to see the others as companions rather than opponents. This way, he accepts his place on a team whose only adversary is the problem to be solved.

3. *Narrow the Areas of Conflict* —No use trying to fight a dozen battles at once. That way, you and the group will wind up in a brawl—or simply thrash around in the same spot and come to no conclusion.

There are four ways in which you can keep the area of conflict narrow, and they are as follows:

• Start with a clearly defined subject and a target time for closing. Make these elements—subject and time—prime parts of your planning. Make the subject narrow enough to explore within the time allotted for the meeting. Announce the subject at the outset of the meeting, state how long the meeting will last and tell what you hope to accomplish by the time the meeting is finished. This way, you'll give the group a sense of direction, purpose and pace—a firm but invisible barrier to those who might want to go astray.

Here, for instance, is a typical opening that will get a group discussion off to a purposeful start:

"In our meeting today we're going to discuss discipline among our employees. That is, how we can get employees to observe our working rules, and what we should do when they violate the rules. It's now eleven o'clock. We'll stop at noon—in time for lunch. If we're going to cover the ground marked out for us, we can't wander off into other areas of discussion. When we break up, I hope we will have framed some specific recommendations about which we can talk with top management and union officials. Now let's start in."

• State the common ground. If you can point out the common ground that the people in your group share, you may save them the time, trouble and debate they would need to discover it.

For example, pick it up where you left off just above—same meeting, same subject, same people:

"Now let's start in. First, I'd like to throw out a few remarks for background. Some of us have more discipline problems than others. Shelton, for example, suspended two men a week ago for smoking in a no-smoking area and another for 'borrowing' a power drill and trying to take it home. I believe Crawford has had only one case—an assembler who was suspended for being chronically late. But I believe we all agree that they're a problem in every department. We agree that no one person among us is entirely to blame. And

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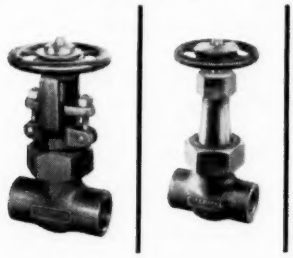

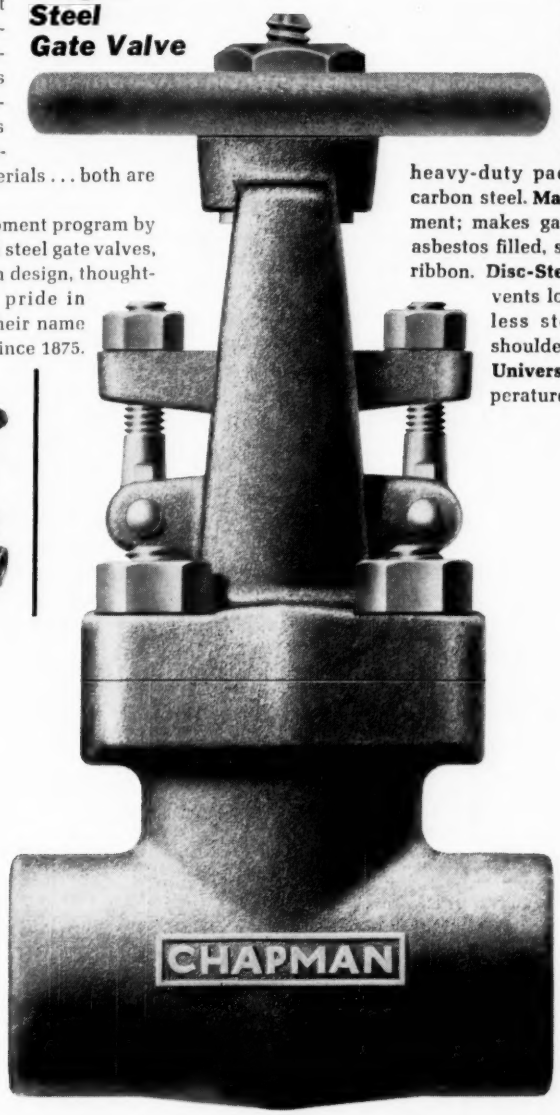

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we agree that the problem won't hold still—either we do something to improve the situation, or the situation will get worse. Finally, we agree that whatever we're going to do, we must do fast. It's our task now to find out what we should do. Would you like to tell us your views, Shelton?"

• Keep the focus on the subject. If your group is like most groups, it will stray from time to time, in spite of all that you do. Talkers will veer over into borderline subjects, reminisce, or drag personalities in. But in meetings of this kind there are always occasional pauses—swiftly passing moments when a man stops for breath, halts to gather his thoughts or fumbles for a word. Also there's always that moment between the end of one man's comments and the beginning of another's. If you're a good leader, you'll seize these moments to haul the discussion back to its base. And if the talk gets too far afield, you should feel no reluctance about breaking into the middle of a man's comments and bringing him back to base.

Can you do this tactfully? Yes. In most situations a friendly reminder is enough: "I know you've had some breakdowns of your plating equipment recently, Rodinski. But I believe we could finish up this meeting on time if we got back to employee discipline."

In other situations, it may take more than a friendly reminder to bring the discussion back to base. You may have to be downright firm. If you do have to cope with this situation, face it. Call the offender to order, politely but positively, and tell him bluntly that he's wasting the time of the group. You owe your group your best efforts to protect it against woolgathering, insolence, ignorance, name calling and other kinds of time wasting.

• Explore one area at a time. Break the subject up into manageable pieces, feed them one by one to your group, clean up each one before you move on to the next.

4. *Keep the Group Under Your Control*—You're the leader. So act like a leader. Make your personality the dominant one. But do it without being domineering.

This is not a matter of personality and tact alone, though these are important. To keep a meeting under control, you need confidence—the confidence that comes from purpose and direction. And you need a firm hand. There will be those who, wittingly or unwittingly, try to take the meeting away from you and run off with it themselves. If you give in to them, you're meeting will be lost—and so will you. These people can be handled—by charm, by wit, by tact, by firmness, by brute strength of character, by rationalizing, or by understanding, depending on the situation and the person involved.

5. *Fix the Purpose of the Meeting*—Shape the procedure that will best achieve that purpose and then move relentlessly toward that purpose.

Business meetings take time. They cost money. So, if it falls to your lot to conduct a meeting, you're duty bound to make it as gainful as possible. Get the most for the time and money that you, your company and the group invest. Be an effective leader.

The 12 skills of meeting leadership

Faith in group achievement. You must accept this fact: though groups can turn into mobs—becoming unstable, highly suggestible and even vicious—they can also be sound, wise, steady and cooperative. If you show your faith in the group, its members will respond with trust in your leadership and with their best talents.

An understanding of people. Individuals, that is. Before you damn a man for being unruly or stubborn or dense, try to find out why he acts the way he does. Understanding him is more than half of the job of getting him to give his best.

Ability to "take it." Sometimes you may feel the people in your group are sabotaging you. Try to remember this: some people just aren't used to making contributions to a group effort. They aren't used to deliberating, investigating or evaluating. They tend to battle—and often make the leader the enemy. Give these people time. Be patient with them. They'll gain experience—see you finally as a skillful leader and pattern their conduct after yours.

Flexibility. Don't cling to rigid rules of order just for the rules' sake. Use rules only to the extent that they help the group to function efficiently. But don't let them stifle discussion or imagination.

A gift for listening. It's the best way of understanding the people in your group—and the only way of seeing how they look at their problems and their world.

Straight thinking. You must be on guard against turns that lead the discussion away from the subject, adroit enough to bring the talk back to the isue or problem under discussion, and sensitive enough to see when an apparent drift away from the subject is really not a drifting at all but the revelation of a new facet of the subject.

Ability to articulate. You must be able to put group ideas and group goals into brief, pointed language, thrown in meaningful comments quickly and clearly, turn the group's groping phrases into crystal-clear phrases, sum up succinctly and state results with strong impact.

Skill in evaluation. You must be alert to conflicts of opinion, spot the main issues, lead the group on to the next point when the time is ripe, distinguish between what's pertinent and not pertinent and sense the time when the group is ready to be led from discussion to conclusion.

Objectivity. You don't have to be cold and impersonal. But you mustn't let your feelings and background stand in the way of logic. If you must state a personal opinion, make it clear to the group that it is personal.

Personal warmth. Use all your sensitivity to the feelings, motivations and needs of the people in your group. Make each person in the group feel you're interested personally in him and that you place a high value on his ideas.

Know-how. Know-how in the field of the problem under discussion, plus know-how about running a meeting. Both ways, you'll build the group's confidence in you as a leader.

A sense of humor. Humor in the best sense, that is. You don't have to be a funny man. Indeed, you're better off not being one. The man with a sense of humor is the man who sees things in perspective—sees people's little failings against the background of their upbringing and their needs, handles their anger and indignation with a light but sympathetic touch, welcomes laughter as relief from tension and resolutely seeks the cheerful and constructive side of everything that comes to light.

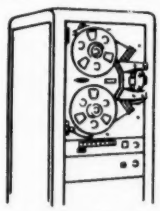
A WORD OF WARNING ABOUT THE NEW ALLUREMENTS OF RECOMP II [and a modest word about price]

Could you be enticed by a computer? Surprisingly, there *are* businessmen and scientists who have allowed their emotions to get quite out of control regarding Recomp II.

And now there is more reason than ever for becoming enamored with this amazing computer. *Three* reasons, to be exact, and all of them new. Hence, our warning to you.

The first reason is, in itself, enough to steal your heart away: it is Recomp II's new reduced lease price. Always the darling of the medium-scale computer user, Recomp II has been so well accepted that it can now be offered at significantly lower terms. And it *still* provides the identical quality, solid-state performance, and features that can't be found on computers costing three times what Recomp II *used* to cost.

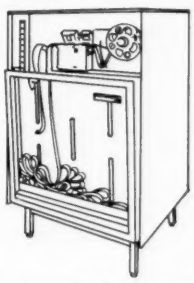
This is heady stuff—but even more enticements lie in wait. You can now add an optional modification to your Recomp II to enlarge its capacity by using magnetic tape. Here you see the new Recomp Magnetic Tape Transport unit.



Naturally it's superbly designed, solid state throughout. But don't let its quietly well-bred air fool you; it has a memory that would stagger an elephant—over 600,000 words. And up to eight of the Transport units can be connected to Recomp II, giving you a computer with a total memory capacity of over 5,000,000 words. Steady there, Mr. Simpson!

The speed of this new magnetic tape control is something to applaud, too: read and write speed is 1850 characters a second; bidirectional search speed is 55 inches per second. Do you begin to see why we warned you about these new allurements of Recomp?

Below you see another new optional feature for your Recomp II: the Facitape tape punch and reader console. It punches 150 characters a second, reads 600 characters a second, and stops on a character. It adjusts to read and punch from 5



through 8 channels. It is versatile, accurate, fast, simple-to-operate, economical, reliable. And it has perfect manners: the mechanical components are completely enclosed in a soundproof housing.

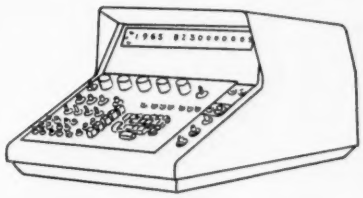
But lest we harp too much on the *new* features of Recomp II, perhaps we had better remind you of some of the extraordinary features that Recomp II *already had*. Features that have always made it the finest computer in the low-priced field.

1] Recomp II is the *only* compact computer with built-in floating point arithmetic. It defies being hemmed in on a problem. With its large capacity it obviates computer-claustrophobia.

2] Recomp II was the first solid-state computer on the market. As you can see by the new features above, Recomp II's scrupulous engineers have seen to it that it remains the *finest* solid-state computer on the market.

3] Recomp II seems to have more built-in features than a dream home kitchen. It has built-in square root command. Built-in automatic conversion from decimal to binary.

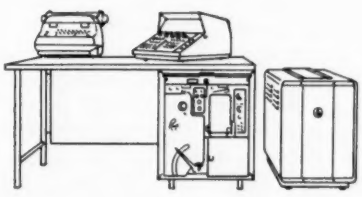
Here you see Recomp II's distinctive keyboard. It looks easy enough to operate—and it *is!* And because Recomp II



requires no specialized talents, anyone with computer problems can be taught to use it.

One look at Recomp II leaves little wonder that even practical people have allowed their hearts to influence them in choosing Recomp II. Without being showy, it is an object of beauty that reflects its supreme precision of performance. Its distinguished exterior bespeaks the ultimate of excellence; *c'est sans pareil.*

But if you want to avoid being captivated by a computer you should know how strong your emotions will run. May we suggest a *test?* Expose yourself to Recomp II. See it in action. Touch it. Feed problems into it. This is the only way to know how you will react to this extraordinary computer. Make a date to see Recomp II right away.



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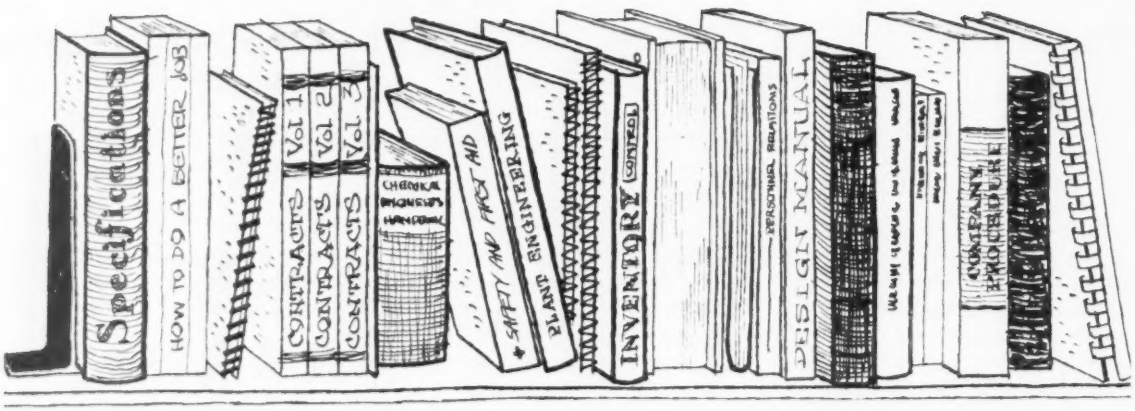
The Autonetics Division of North American Aviation, Inc.



Elements of Operating Manuals

A single source for plant operating data, specifications and emergency procedures is essential to efficient startup and operation.

J. E. TROYAN, *Olin Mathieson Chemical Corp.*

Operating manuals are indispensable to successful plant startups and trouble-free plant operation. They contain the summation of general knowledge on the process, describe the methods for operating the plant (standard operating procedure), and usually serve as basic training manuals and reference works for the project.

Supporting documents, such as The Basis for Design, Equipment Specifications and Analytical Methods for Quality Control are often included with these manuals.

Personnel involved in plant startups and operation must have a good understanding of (1) process design, (2) variables affecting yields, quality and continuity of operation, (3) performance characteristics of major equipment and (4) provisions for personnel and equipment protection in emergencies. All such information should be in the operating manual.

The standard operating procedure (SOP) section is basically a startup guide that may not necessarily define the optimum manner of operation. In time, ideal procedures and techniques for the most efficient and safest performance will be established. The initial writeup gives a standard approach that must be followed by different shifts to produce continuity. As operation proceeds and experience is gained, SOP's will be altered. Safety, economy, sustained production and quality must be considered in determining them.

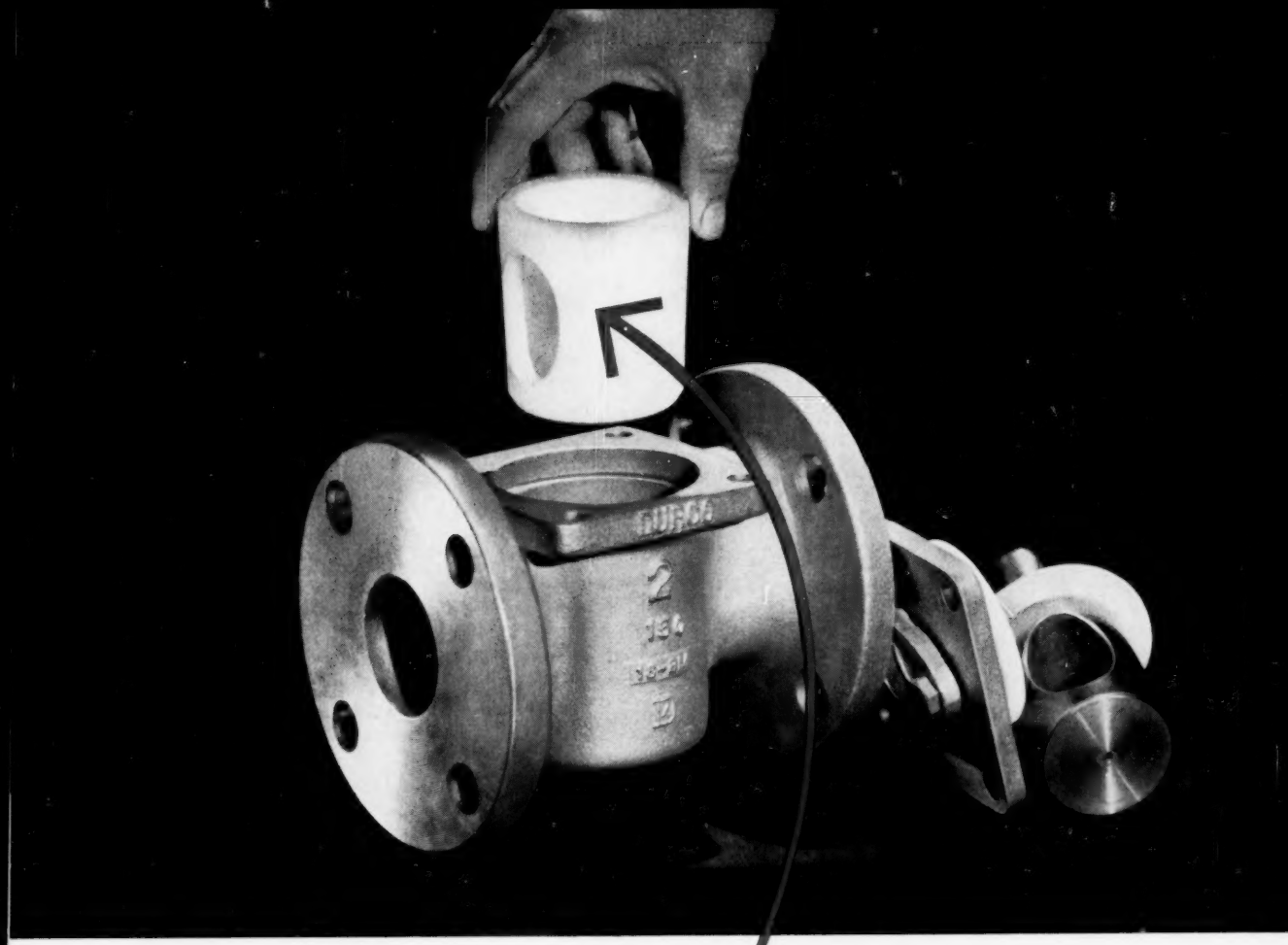
Table I summarizes a comprehensive outline for an operating manual. Detail required for a large job can be reduced significantly when a smaller project is involved.

Writing Must Be Clear

The author of an SOP must write in a manner that provides for sufficient flexibility when new or unexpected situations arise. Experienced operating supervisors can then make on-the-spot decisions in interpretation of the SOP, without deviating from the basic intent of the instruction.

The text of the manual should be written clearly and concisely—there is no place for ambiguity. It is also best for the writer to use the imperative mood throughout.

Information on process equipment or mechanical features of the plant is often consolidated in a separate supplementary volume to the operating manual that may be entitled "Mechanical Catalog," "Manual of Plant Equipment," or "Equipment Specifications." In any event, this section will include design and operating specification sheets and sketches on pumps, heat exchangers, compressors, reactors, columns and other process equipment. Manufacturers' special instructions for assembly, repair and servicing of the equipment might also be included. Sometimes, spare-



IT'S THE SEAL THAT COUNTS

A heavy Teflon® sleeve is the heart of the Durco SLEEVELINE® non-lubricated plug valve. Teflon's lubricity, pliability and chemical inertness provide nearly perfect resistance to sticking, leak through and corrosion.

The Durco designed sleeve completely surrounds the plug. Its large sealing area will withstand erosion, nicks, scoring and general wear for years in process liquid, gas or slurry applications. And it's heavy enough to allow up to ¼" vertical adjustment for wear.

Durco SLEEVELINE valves are designed and priced to replace ball valves, and lubricated plug valves wherever they are in use. Write for your copy of Bulletin V/12a.

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THE DURIRON COMPANY, INC., Dayton, Ohio / Valves • Pumps • Filters • Process Equipment

Outline of an operating manual—Table I

A. Table of contents.
B. Introduction—scope, history, general background.
C. Description of process.
  Simplified—general.
  Chemistry of process—material properties, material specifications, analytical methods.
  Process steps in detail—effect of primary variables.
  Controls, instrumentation.
  Waste disposal, pollution data, special venting methods.
  Materials of construction.
  Material balance summary, yields, byproducts.
  Process and engineering flowsheets.
    Hourly, batch quantities—weights, moles; time cycles.
D. Safety considerations.
  Hazards—fire, explosion, health.
  Procedures.
E. Preparations for startup.
  Cleaning, flushing, hydrostatic testing.
  Mechanical checks and preliminary operation.
  Lubrication of valves.
  Final drying and/or purging.
F. Operating procedures.
  Normal operations—startup and shutdown.
    (Standard conditions, flows, etc.)
  Data to record, log sheets.
  Emergency shutdown—what to do if various situations develop.
  Samples and process control analyses.
G. Description of utilities.
H. Description of process equipment.
  Types and purposes, maintenance aspects.
  Operating characteristics, inspections.
  Instrumentation specifications.
I. Miscellaneous containers, labor needs.

parts lists will be incorporated, though these are often assembled independently by the maintenance or engineering group.

Though not convenient for inclusion in an operating or equipment manual, detailed engineering drawings may be edited, reduced to $8\frac{1}{2} \times 11$ in., or other suitable size, and bound into the specification section of the manual for ready reference.

Supplementary to the operating and equipment sections of the manual may be a special "Basis for Design" report summarizing significant laboratory or pilot-plant data, miscellaneous data from the literature, as well as the original proposals for plant layout, equipment selection, operating procedures, safety considerations and other data of value to the design and production people.

What material should be covered in the major sections of the operating manual?

Description of Process: This section should cover the basic objectives of the plant and discuss the individual process steps involved. It will review the basis for design, describe the chemistry, kinetics and yields of reactions, and list the physical and chemical properties and specifications of raw materials, intermediates, byproducts and products.

Here will also be described methods of instrumentation and analytical controls. If any special problems on waste disposal, air or stream pollution, and corrosion are expected, these too should be discussed here. Engineering and process flowsheets, complete with material and heat balances, should also be included.

Safety: Any hazards involved in equipment operation or handling of chemicals in the process should be clearly defined in this section. Toxicity, fire or explosion problems should be spelled out. Methods for protecting personnel and plant from toxic exposure or injury should be delineated. Brief instructions on the use of first-aid equipment or procedures should be included, but more detailed information should be supplied in training classes or on-the-job.

Preparations for Startup: This part of the manual should take care of the transition between construction completion and operational startup, and should describe methods of cleaning, purging and flushing of lines and equipment. Where desired, it will specify follow-up pressure testing beyond that done during construction.

Checkout of pumps, motors, compressors and similar mechanical or electrical units is recommended, usually in cooperation with the contractor. Instrument checkout for proper tie-in and valve action is likewise covered in this phase.

Chemical activation of catalysts or dryers may or may not be indicated in this section of the manual. Some project managers prefer to consider such work under initial operation.

Operating Procedures: This section is really the heart of the operating manual. Here are described in detail the step-by-step procedures to be followed in operating the individual pieces of equipment in the plant. How these integrate into the overall process, key process conditions involved, corrective action under various circumstances and general techniques of operation, will be covered.

Very often, check lists on valves to be set or sequences to be followed are provided. Standard operating procedure sheets that can be posted near equipment are often used. These may be included in the operating manual, as such, or they may be simplified, itemized procedures that have been digested from the manual.

Emergency procedures to be followed in the event of abrupt shutdowns, fires, explosions, power outages, etc., are an important part of this section.

Quality control tests, samples and analyses are also conveniently described here.

Finally, this section should provide for standard log sheets for recording of data from which process yields and other process information can be calculated.

Description of Utilities: This portion of the manual describes steam and condensate systems, water supply, refrigeration and electrical systems. If desired, it could also describe such other utilities or auxiliary items as compressed air, inert gas, fuel gas and control lube systems, flare or process blowdown systems and fire protection facilities.

Capacity, nature and location of the system and method of distribution are summarized in most cases.

Relative quantities used in various process areas

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SWIVEL JOINTS..

modern joints you can

WELD

into the line!

Now you can say..

goodbye to leaky threads C-E joints welded into loading arms eliminate excessive maintenance costs caused by dripping caustic fluids.

goodbye to costly flanges C-E weldable joints eliminate need for flanged connections when fabricating loading arms.

goodbye to higher installation costs C-E weldable joints are easier and faster to install, lower priced and stronger, too.

goodbye to time-consuming packing replacement C-E weldable joints can be repacked when necessary without removal from loading arms.

Continental-Emsco's patented design permits bearings to remain in place *even during* packing replacement or adjustment. Simply loosen set screws and turn body. Joints break like a union, exposing *only* the packing .. bearings are *never* disturbed. Wide spacing of high capacity bearings .. another exclusive C-E feature .. permits greater foot-pound loading on the joint. Additional features include on-location replacement of worn parts .. elimination of split bearing races for added strength .. reversible races on most joints for double service life.

Write today for our new catalog on C-E's modern line of swivel joints.

C-E joints are manufactured for practically all petrochemical and chemical services. Sizes are available from 3/8" to 12" diameter in steel .. from 2" to 12" diameter in aluminum. Joints are also available in threaded or flanged styles for replacement in existing systems.

SJ002

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Industrial Products Division
P. O. Box 359,
Dallas 21, Texas

are tabulated and often serve as a basis for proration of utilities costs.

Description of Equipment: As we have already mentioned, it might be desirable to segregate detailed data in support of this section in the Equipment Specification Catalog. However, this section should still provide text explaining the purpose and method of using and maintaining the equipment. It would include operating curves for pumps or compressors, ratings on safety valves and rupture disks, port sizes of control valves, orifice sizes and related instrumentation data.

If there is no separate book for equipment specifications, such information should at least be summarized here.

Special instrument or electrical control systems should be described in this section. It is also a good idea to include calibration data on tank volumes, flow rates, etc., at this point in the manual. But, on the other hand, such information may be tabulated for more ready application in the actual operating procedures or with the posted SOP's.

Sometimes, this section should contain purchase order numbers, vendors' names, equipment property numbers, etc., for quick reference when outside contacts on equipment are required.

Miscellaneous: Certain other pertinent data, not mentioned before, should be included in one of the sections of the manual or in the supplementary Basis for Design. This would include specifications for product containers, shipping procedures, ICC regulations, time cycles in batch operations, labor requirements and scheduling, routine equipment inspection and so forth.

Provision should be made in the format of the operating manual for SOP change sheets. When revisions in the procedures are required, formal replacement pages should be issued. Reference to the reason for the change and the anticipated results should be made.

Who Prepares the Manual?

Operating manuals can be prepared in a number of different ways. They may be supplied by the contractor on a major project, or they may be written by company personnel who cooperate to prepare different sections.

Operating foremen can prepare major sections, particularly the detailed Standard Operating Procedures. These men can often incorporate a down-to-earth operating viewpoint that might be missed if the procedures were prepared by process engineers with limited operating experience.

Meet the Author

J. E. TROYAN *is production manager of Olin Mathieson's Doe Run plant at Brandenburg, Ky. He is also the author of "How to Prepare for Plant Startups," in our Sept. 5, 1960, issue.*

FIND OPTIMUM FREQUENCY OF INSPECTION

Too much inspection can cost money; too little could be disastrous. Statistical analysis can help find the happy medium.

DR. ING. GIULIANO SIGNORINI
Impianti Chimici—Politecnico Milano

Any properly coordinated maintenance program incorporates routine inspection procedures for preventive maintenance.

We have developed such a routine inspection procedure for determining the economically optimum frequency for plant inspection of auxiliaries installed in homogeneous lots of similar units operating under the same conditions. Steam traps, control valves and instruments would qualify under this definition.

We will illustrate the procedure with steam traps.

Let us take a lot of N steam traps installed in any chemical plant employing steam heating. These units are subjected to normal wear and consequently go out of service in time. Because there are many units installed, we can estimate an average life for any one unit during which it will operate efficiently. But there will come a time in the life of the trap where steam losses will become excessive and the trap must be removed and repaired and/or replaced.

How often is it expedient to inspect all our traps to find those few that are malfunctioning? We must determine an optimum inspection frequency that will balance the costs of inspection and repair against other losses that might be incurred by leaving bad traps in service. We thus arrive at the optimum frequency of inspection by finding minimum total cost.

Starting from time $t_o = 0$ when each unit of the lot is working efficiently (some because they are new, some because they have just been repaired and others because they are at an intermediate state of wear) we make preliminary inspections at regular intervals.

We repeat these inspections n times during a period

In every operation that calls for QUICK, TIGHT CONNECTIONS

Install EVER-TITE Couplings

You get tight, safe connections that *prevent leakage and losses* when you install Ever-Tite Couplings—because in every Ever-Tite, tightness is pre-determined and built in by compression on a resilient gasket.*

And you make faster changes—reduce down time—because Ever-Tites are *quick* to connect: you just slip the coupler over the adapter and close the handles.

This speed and flexibility is an important time saver in making connections between stationary equipment and portable equipment, and for interchanging couplings in experimental set-ups.

It will pay you to install Ever-Tites on all equipment that requires quick connections: loading equipment for tank cars, trucks, etc. . . . steam, air and water lines . . . pumps and other machinery . . . blending equipment . . . container filling devices . . . fire hydrants . . . acid handling equipment at storage and transfer locations.

Available in Brass, Malleable, Stainless, Aluminum, Monel, or other materials for corrosion resistance under any atmospheric or operational conditions. In sizes, high and low temperatures, and pressure ratings to meet *your* needs, produced to meet ASA ratings—specify size and pressure.

Write today for illustrated catalog No. C-11.

*Ever-Tite gaskets are regularly supplied of Buna N composition. Also available in Neoprene, Pure Gum, Butyl, Silicone, Teflon, Thiokil, or any other material to meet specifications.

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EVER-TITE
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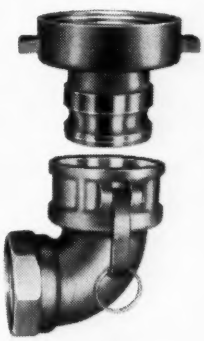
and Coupler



EVER-TITE
Adapter and Coupler
for Tank Car Unloading

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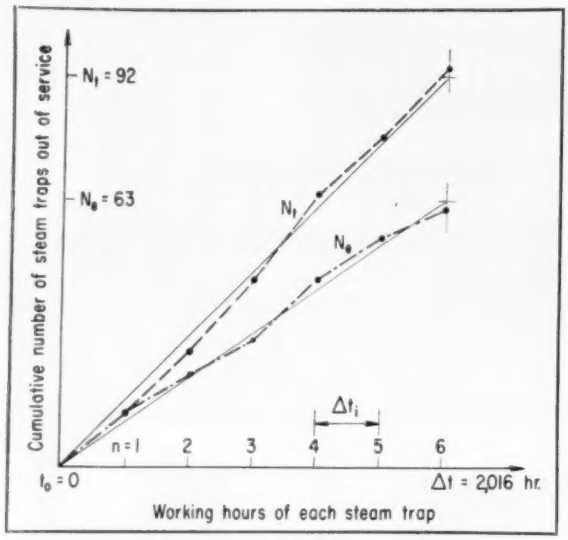
Cumulative values of N_t and N_e vs. time.



Δt (expressed in working hours of the units) repairing any traps found out of service after each such inspection. We label these repaired traps so that we may readily identify them during later inspections should they again fail.

In each inspection, we will find a certain number of traps out of service. Of these, some will have failed for the first time from the beginning of the period (i.e. from time t_o) while some will have failed before and will have been found and repaired during previous inspections (as can be ascertained by the labels attached to the traps in question).

The total number of failures during the time from t_o to t_n will be called N_t. This number could be larger than the number of traps since some of the traps quite possibly will fail more than once. The number of individual traps which fail during this time (counted only once for each trap even though it failed more than once) will be called N_e, or the "effective" number of traps that we would find out of service at the end of the period Δt if none of the traps that had failed at previous inspections had been repaired.

If we plot the cumulative values of N_t and N_e against time, we get straight lines as a first approximation (see chart).

Meet the Author

GIULIANO SIGNORINI *is assistant lecturer in the chemical plant design dept. at the Polytechnic of Milan, Italy, and lecturer in the industrial engineering dept. at the University of Pisa. He is also an industry consultant and a member of Associazone Italiana de Ingeneria Chimica and Societa Chimica Italiana.*

While N_e does not obviously depend on the number of inspections made during the period Δt (being statistically related only to the severity of the working conditions and to the types of traps themselves) we may assume that N_t is at any time approximately proportional to both the number of inspections and the number of traps installed, N.

Thus:

$$N_t = N_e + KN\,(n-1) \tag{1}$$

where K is experimentally determined from the cumulative values of N_t and N_e at the end of the period Δt.

With n regular inspections during the period Δt, the cost for trap testing is:

$$S_t = C_t N n \tag{2}$$

where S_t is the total testing cost and C_t is the cost for testing each trap.

The cost of repairing traps found out of service after each inspection is:

$$S_r = C_r N_t = C_r [N_e + KN\,(n-1)] \tag{3}$$

where S_r is the total cost of repairs and C_r is the cost for repairing each trap.

The cost of steam losses from traps that have gone out of service between successive inspections is:

$$\begin{aligned} S_L &= \sum_1^n \int_{t_o=0}^{t-\Delta t_i} (L\,N_t\,dt) \\ &= \frac{L\,N_t\,\Delta t}{2n} \\ &= \frac{L\,\Delta t}{2}\left(\frac{N_e}{n} + KN\,\frac{n-1}{n}\right) \end{aligned} \tag{4}$$

where S_L is the total cost of steam losses and L is the hourly loss from a single trap out of service.

Over-all cost, then, is:

$$S = S_t + S_r + S_L \tag{5}$$

This over-all cost is a minimum for a certain number of inspections, n_{opt}, made during the period Δt. We can find this optimum number of inspections with the following equation:

$$n_{opt} = \sqrt{\frac{L\,\Delta t\,(N_e - KN)}{2N\,(C_t + C_r K)}} \tag{6}$$

Where the System Came From

We had a lot of 128 medium-pressure steam traps installed, which we inspected every two weeks. Over a period Δt of 2,016 working hours, we made six inspections and tests of all these traps. At each inspection, a total and effective number of traps were found out of service and these cumulative values for N_t and N_e were plotted as in the chart. For the entire period, we obtained the interpolated values for N_t and N_e of 92 and 63, respectively. From Eq. (1), we calculated K to be 0.045.

The cost for testing each trap, C_t, was 10¢ since it took a worker earning \$1/hr. six minutes on each one. The cost for repairing each trap was \$3 including transport to the workshop and reinstallation.

Each trap out of service, with steam costing \$1.38/1,000 lb., costs approximately 8¢/hr. in steam losses.

How to buy a ball valve!

Check these features!

	FLO • BALL	VALVE A	VALVE B	VALVE C	VALVE D	VALVE E
1. TOP ENTRY	√			√		
2. IN-LINE MAINTENANCE	√			√	√	
3. TOP AND BOTTOM GUIDED BALL	√					
4. DOUBLE SEATS	√	√	√	√	√	√
5. FLANGES INTEGRAL WITH BODY	√	√		√		
6. ONE-PIECE BALL AND STEM	√					
7. BLOCK AND BLEED	√					
8. COMPETITIVELY PRICED	√	√	√		√	√

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In addition to these outstanding features, the **FLO•BALL** valve, with all teflon seats and seals, offers all of these advantages which make it far superior to other types of valves: fast ¼ turn, minimum pressure drop, leakproof shut-off, visible on-off indication, no backlash, and the lowest torque of any valve. The **FLO•BALL** can never stick or freeze, and it lasts longer, with less maintenance, than any other valve made.

HYDROMATICS offers the most complete line of industrial ball valves, including 1" through 14" flanged, 150#, 300# and 600#, all built to ASA dimensions. Also available: ⅛"—2" screwed end valves to 3000#.

HYDROMATICS is the world's most experienced ball valve manufacturer, having built ball valves to 10,000 psi and 14". See your local distributor for details and prices, or write to:

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FLO-BALL

Therefore, we can calculate the optimum frequency of inspection with Eq. (6) as follows:

$$n_{opt} = \sqrt{\frac{0.08 \times 2{,}016\,(63 - 0.045 \times 128)}{2 \times 128\,(0.10 + 0.045 \times 3.00)}} = 12.4$$

which corresponds to about one inspection every week instead of one every two weeks as had been our practice.

We realized a saving of about $900/yr. on these 128 steam traps, which does not include the resulting improvement in efficiency of steam-consuming equipment.

In areas where labor is expensive and the item in question is relatively cheap, it may be more economical to throw away the defective item rather than attempt to repair it. This situation is easily handled by this inspection system—just substitute the cost of the item for C_r, the cost of repairing it.

BEWARE OF WATER AND AIR IN YOUR PROCESS

Did you know that water in a confined space will increase in pressure 50 psi. for each degree rise in temperature? And this at near-ambient temperatures? At higher temperatures, the pressure rise can be as great as 160 psi. per degree rise in temperature.

Did you also know that simply opening a valve in a hydrocarbon-containing system can catalyze an explosion? It seems that the new, clean metal that is exposed when the valve disk lifts off its seat can catalyze a reaction between the hydrocarbon and any oxygen that might be present.

These two interesting items are contained in a couple of booklets entitled "Hazard of Water in Refinery Process Systems" and "Hazard of Air in Refinery Process Systems" or, more simply, "Booklet Number One" and "Booklet Number Two," respectively.

Published by The Standard Oil Co. (Indiana), these two booklets are the first in a series that so far numbers four, all of them dealing with process safety in refineries. (The last two of the series deal with lighting-off boilers and refinery turn-arounds.)

Though primarily aimed at refinery operators, the booklets can be most useful in the chemical industries, too. Indeed, in some segments of the CPI, where perhaps the more obscure hazards of air and water are not too well known, knowledge gained from these handbooks could literally be a lifesaver.

Booklet Number One contains 69 information-packed pages ranging from the nature of water and steam, to references for additional reading. In between, there is much on the proper engineering and design of process equipment on how to keep water from accumulating in the system in the first place.

Proper operating techniques for keeping water out of the process or for eliminating it safely are also discussed at length. And there are brief discussions on water as a source of air, and water as a static generator.

The handbook is lavishly illustrated throughout with photographs and drawings. Some readers may find the cartoon on p. 23 particularly amusing.

Booklet Number Two is quite similar to Number One except that it deals with hazards of air and oxygen and is a little shorter (63 pages). This handbook devotes a great deal of space to discussion of the fundamentals and theory of combustion and detonations. As you might expect, the emphasis here is on design and operation such that fires, explosions and detonations will not occur. (Explosions and detonations are not necessarily the same.)

Both booklets are now in their fourth editions, newly revised in 1960. They are available to the industry at cost from The Standard Oil Co. (Indiana), Chicago, Ill.—PJB

BY POPULAR DEMAND

In our December 12, 1960, issue, we published an article in Operation and Maintenance entitled "How to Set Up Shift Schedules" by Ralph H. Wing. We are now offering reprints. Just circle number 175 on the reader service card. The price is 50¢.

CE to participate in Disaster Conference

Plan to be in Houston from April 18 through April 20, 1961. That is when the National Institute for Disaster Mobilization (NIDM) will hold its Fifth Annual Industrial Mutual Aid and Disaster Control Conference, at the Shamrock Hotel.

Editors of *Chemical Engineering* will be there to conduct a panel investigating a disaster involving Stardust Chemical Co., our mythical refinery and petrochemical plant that has worked itself out of many a nasty situation in the past. (See *CE*, Dec. 1957, pp. 237-252; July 14, 1958, pp. 130-140; Aug. 10, 1959, pp. 113-124.)

But *CE*'s panel will be only one of many interesting and informative panels, talks, discussions and workshops covering the entire field of industrial mutual aid and disaster control, including "In-Plant Disaster Control," "Industrial Mutual Aid for Disaster Control," "Radiation Hazards" and "Industrial Mutual Aid in Natural Disasters." The theme of the conference will be "Profiting by Experience."

There will also be a boat trip down the Houston Ship Channel with displays of emergency equipment, a fire-fighting demonstration and a running commentary on the industries along the channel with discussion of the hazards involved.

For more information, contact the NIDM, 475 Fifth Ave., New York 17, N. Y.

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"METALS FOR PRECISION AND PERFORMANCE"

New Materials: Better Plant Repairs

Unique and more resistant materials—from acrylic windows to metal-filled plastics—are available for reducing maintenance in chemical plants on floors, roofs, walls, pipe.

One of the biggest challenges faced by chemical process companies in the challenging 60's is how to reverse the trend of rising costs and declining profits.

Many aspects of production costs are, and will be, critically examined by chemical engineers in attempts at bucking this trend. But any really competent study should not overlook an area often neglected from a cost-saving standpoint. This involves reducing maintenance on the chemical plant itself—roofs, floors, walls, windows—aside from process equipment.

A number of new and unique materials and methods are available for repair and improvement of such troublesome items in chemical plants as concrete floors, asphalt roofs, glass windows.

▶ **For Better Roofs**—Majority of industrial plants have flat or sloped roofs with coverings of rag or asbestos felt, saturated and bonded with asphalt or pitch. Many flat roofs are topped with a hot mopping of pitch or asphalt, then graveled.

These roofs deteriorate from the effects of weathering and mechanical damage. Light, heat, wind remove the asphalt binder and leave felts dry and brittle. In the past, repairs have been limited to hot-mopping the exposed surface, or patching with some sheeting, or replacing the entire roof.

Now, newer and better materials are available. For instance:

- Fiberglass fabric with tear strengths far in excess of felts for use as flashing or patching.
- Plastic screen fabric for reinforcing fiberglass or felts.
- Synthetic elastomer flashings for difficult locations such as around sheet metal or plastic ducts.
- Special, cold-applied mixtures of asphalt, synthetic rubber, silicones and plastic, applied on a cleaned roof to resaturate the top layers of felt. On large areas, a pump and hose move the material from drums on the ground to the roof. Cost of this application is usually less than a hot-mopping of asphalt or pitch.
- Special, hot-application mixtures of asphalt, silicones and plastic, sprayed under pressure and heat, to the cleaned roof to resaturate top felt layers. Hot mix is applied at about 250 F. (usually by a contractor).
- Spray application of asphalt and chopped fiberglass woving directly on a new deck or over old roofing. Asphalt emulsion is stabilized with a clay colloid for protection against degradation and blistering. Flashing is easily covered. The roof is tight but has enough elasticity to take care of expansion and contraction. Repairs are readily made with a patching compound. A three-man crew can roof 15,000 to 18,000 sq. ft. a day using this method, in contrast to five men putting down 8,000 sq. ft. a day with the conventional layer-mopping technique.

▶ **Improved Insulations** — Some new materials are also on the market to improve roof-insulation properties. Cork, cane board or fiber-

Plastic coating of pipe becoming big business

Plastic coating the internal surfaces of oil field tubing and drill pipe was practically unknown about 5 yr. ago. Now there are about 10 plants in the Southwest devoted exclusively to this type of work. One of the biggest firms in the field, Plastic Applicators, Inc., Houston, Tex., has four pipe-coating plants in Texas and Louisiana with a total coating capacity of 1 million ft. of pipe per mo. The company has just opened new research laboratories in Houston for improving plastics. One of the interesting operations in coating pipe: mechanized spraying lances (above) moving from oven to oven, spraying plastic inside the pipe.

Sulphur Compounds Causing Corrosion?

...Test **HAYNES** Alloys

The combination of sulphur dioxide or hydrogen sulphide *and moisture* spells trouble! Expensive trouble . . . in terms of corroded equipment. Yet even these tough combinations can be handled safely by HASTELLOY alloys C and D. Both alloys are highly resistant to these moist gases up to 160 deg. F.

Sulphur alone causes costly corrosion damage, too. In one plant, traces of sulphur dioxide and trioxide in a light hydrocarbon stream caused severe pitting. Seventeen alloys were tested on stream . . . 16 pitted. Only one . . . HASTELLOY alloy B . . . emerged unmarked.

There are 9 HAYNES corrosion-resistant alloys developed during a 30-year concentrated study on corrosion problems and metals best suited to solve them. You can capitalize on these years of experience.

Send for test samples . . . Write us a letter outlining your corrosion problem. We'll send a free test sample of an alloy best suited to resist it. Address your letter to Haynes Stellite Company, 270 Park Avenue, New York 17, N. Y. Descriptive literature available.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY

Division of
Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

"Haynes," "Hastelloy," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

". . . Epoxy flooring materials are fast becoming standard for chemical, abrasion and impact resistance . . ."

glass have been available for some time. But a new aluminum-filled asphalt-base coating does an excellent job of reflecting the sun's rays. Also, a thin aluminum sheet can be applied with a hot or cold binder to clean, nongraveled roof surfaces to reflect the sun. This sheet is more difficult to install than a coating but does a better insulating job.

Another approach is to use volcanic-glass, bonded with a thermoplastic. In this method, the old, uninsulated asphalt roof is not removed (it acts as a vapor barrier). All loose gravel must be taken off, however, and any blisters opened and patched. Insulating material is mixed on the job in a special truck-mounted mixer, and spread hot on the roof to correct depth and contour. It is then raked and compacted with a roller. Approximately 2½ in. of this compacted material has the same insulating qualities as 2 in. of cane board. Rot- and vermin-proof, as well as fire-resistant, the insulation is less costly to install than cane.

▶ **Replace Glass** — In industrial plants, window modernization with some of the new materials can give a building new life and substantially simplify maintenance.

For instance, one of the most versatile replacements for glass is the translucent panel formed by soaking a dense blanket of fiberglass in a polyester resin. Glass fiber and resin are cured in a mold to yield strong, translucent flat or corrugated sheets. These sheets show little tendency to crack or glaze when subjected to impact.

However, fiberglass-polyester sheets are not good where transparency is important. Here, acrylic materials (polymethacrylates) have become popular, particularly for areas where glass breakage is high. Acrylic sheets are very resistant to impact, twisting and shock. The material will scratch, so it must be protected with adhesive paper during installation and a nonhardening putty is used to set the sheets in the sash. Acrylics are more expensive than glass but can be justified where glass maintenance is high.

In many plant areas, steel sash will corrode due to fumes or moisture. One solution to this problem is to remove the sash and install glass block. This is mortared into a permanent setting with an epoxy material. Result is a smooth surface, impervious to moisture and easy to clean. Another way to avoid corrosion problems: use aluminum sashes.

▶ **Plastics Cover Floor** — Rapid growth and adoption of mechanical handling equipment has subjected plant floors to abuse that was never originally contemplated. A number of patching and overlay materials have been developed to overcome this situation. For many years, these patching compounds had asphalt or bitumen bases. Now, newer materials do a much better job.

A latex-modified portland cement mixture containing vinyl, acrylic, or rubber, can be used to patch or resurface concrete, wood or steel.

Epoxy floor surfacing and patching materials are fast becoming standard where chemical resistance combined with resistance to abrasion, wear and impact is required. Material is applied over clean, sound, dry concrete by hand troweling or with new spray techniques (see *Chem. Eng.*, Jan. 9, 1961, p. 130). Material must be placed reasonably fast, since working life is usually about 60 to 90 min. Curing time is 8 to 12 hr., after which the surface can be put into service.

Where a smooth, nonslippery, water-tight covering is necessary, neoprene-latex overlays are becoming very popular. This material can be applied over wood or deteriorated concrete. A reinforcement of cloth is usually put down first over the old concrete, and then alternate layers of the neoprene overlay and burlap are spread and worked together to form a smooth surface.

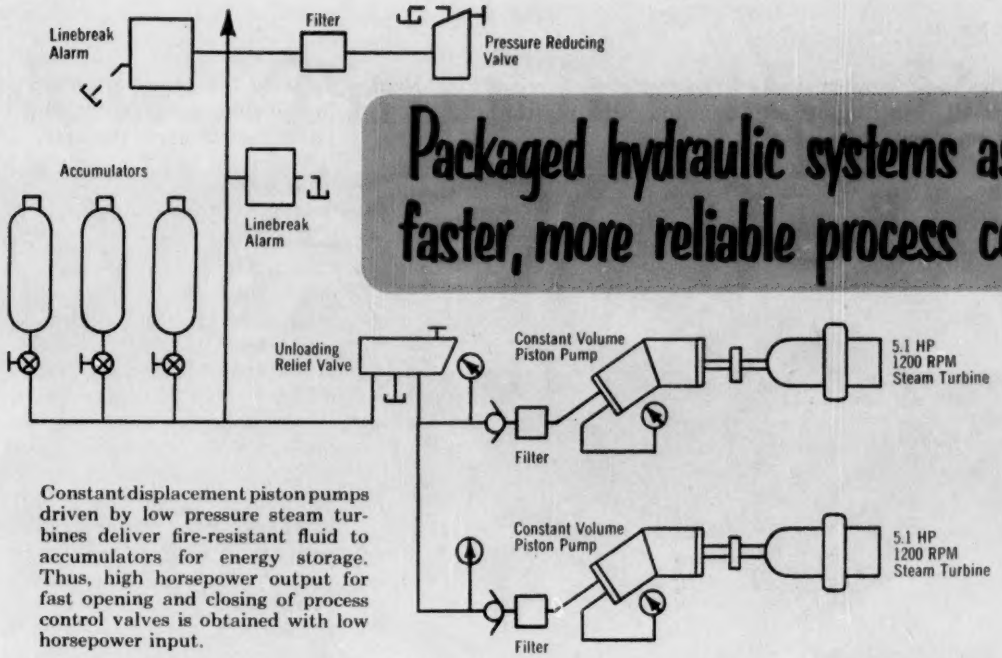
▶ **New Concrete Adhesive** — Mention should also be made of a new concrete adhesive: liquid polysulfide polymer, which cures to a flexible solid without shrinkage. The material is a good "flexibilizer" for epoxy resins. Combining the two makes an excellent concrete adhesive that is strong, flexible, and does not shrink. When applied over old, properly cleaned concrete, it will bond it with a new concrete layer—and the bond is stronger than fresh concrete-to-concrete. This adhesive permits easy repair of flooring attacked by chemicals.

▶ **Developments in Epoxy Patching**—One of the most useful materials developed for plant repairs are the epoxy patching compounds. They are available as a plain resin, or mixed with powdered stainless steel, aluminum, lead. When mixed in the proper proportions they can be used to:

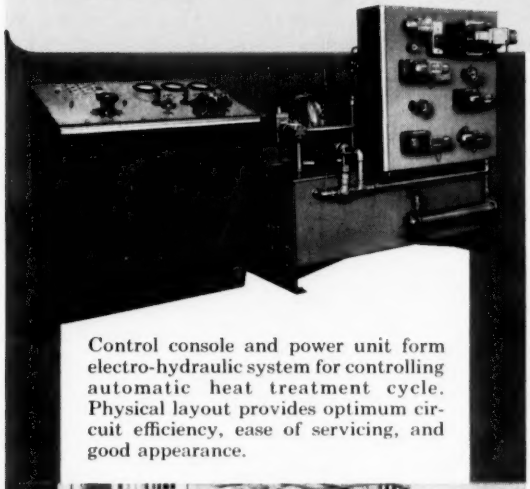
- Fill in and tighten loose gear and pulley hubs on shafts.
- Prevent nuts from becoming loose on shafts where lock washers have failed.
- Fill in and hold bearings in end bells of motors instead of boring and bushing to size.
- Seal around rivets on a tank instead of welding (areas sandblasted to secure clean surface).
- Patch defective spots in plastic- or lead-lined reaction tanks.
- Set electrical junction boxes on concrete and brick walls to replace mechanical anchors.
- Fill blowholes or holes that have been machined incorrectly in castings.
- Make devices such as jigs, fixtures and nests, for holding irregular shaped parts.

For repair of process lines, a number of techniques using patching compounds have been developed. Some involve wrapping epoxy-impregnated glass cloth around the leak. Others call for forcing catalyzed epoxy resin into a tape mold built up around the leak (a screen wrapped around the leak serves as framework for the epoxy). After hardening for about 2 hr., the line can be put into use.

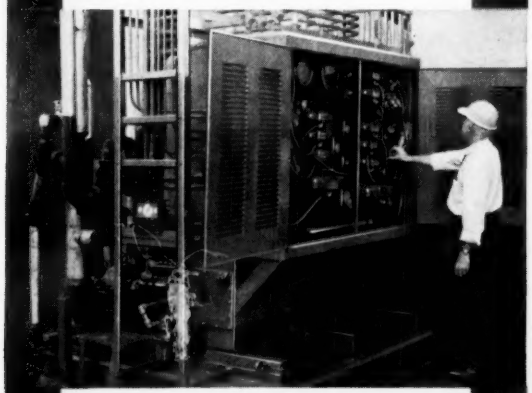
Packaged hydraulic systems assure faster, more reliable process control



Constant displacement piston pumps driven by low pressure steam turbines deliver fire-resistant fluid to accumulators for energy storage. Thus, high horsepower output for fast opening and closing of process control valves is obtained with low horsepower input.



Control console and power unit form electro-hydraulic system for controlling automatic heat treatment cycle. Physical layout provides optimum circuit efficiency, ease of servicing, and good appearance.



This power package includes all hydraulic pumps and valves for complete control of automatic cyclic operation of process in a butadiene plant.

Fast and precisely controlled motions, having the high reliability demanded by modern processing, are inherent characteristics of hydraulics. In addition, these advantages are obtained at low cost, for you can cover your full range of operations—from valve control to power transmission—with standard Vickers components. Your engineers enjoy unlimited design flexibility through a choice of electric, electronic, pneumatic and manual signals to control the hydraulic pumps, motors, cylinders, and variable speed drives.

Vickers complete packaged systems are ready to go into service upon arrival in your plant, since they are thoroughly pretested before shipment. They are properly designed and built to give maximum service life with little downtime, thus helping to keep your plant on stream.

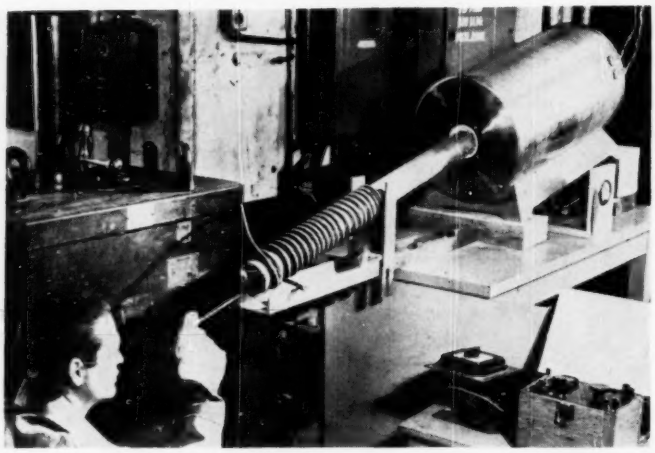
Get more information on the job being done by Vickers packaged hydraulic systems in chemical, petrochemical, petroleum refining, and other processing industries by writing today for Bulletin I5802, "Packaged Hydraulic Systems for Process Control."

VICKERS INCORPORATED
DIVISION SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1400 • Detroit 32, Michigan

9138

A new plastic-pack unit permits mixing of small quantities of resin and curing agent without exposure to air or skin. Epoxy is in a sturdy clear plastic bag with the curing agent in an attached collapsible tube. Curing agent is injected into the resin and mixed by hand-kneading the plastic bag.

Based on a talk by Kenneth N. Banthin, plant engineer, Visking Co., div. of Union Carbide Co., Chicago, Ill., at 12th Plant Maintenance and Engineering Conference, held concurrently with the 12th Plant Maintenance and Engineering Show, Chicago, Jan. 23-26, 1961.



New Copper-Joining Process

Low-cost diffusion method yields much stronger, more resistant copper joints, compared to standard techniques.

A new diffusion method for joining copper-to-copper, and copper to certain alloys, has been developed by Chase Brass & Copper Co.

Joints are far superior to soldered connections in tensile, shear and fatigue properties. Corrosion resistance is also expected to be much better than soldered joints. And the new technique is not expensive.

▶ **Diffusion Technique**—In the process, a special coating on the metal surface diffuses into the parts to be joined, producing a strong, homogeneous bond without any interface. Joints retain virtually all of the high electrical and thermal conductivity of copper.

Coating can be applied to copper strip before it is rolled to finished gage, or to fabricated parts. Several types of bonds can be made: complete diffusion, braze, and combined diffusion and braze. One type may be more suitable for a specific application, but all make highly satisfactory joints.

Coated strip can be annealed in a nonoxidizing atmosphere at moderate temperatures and fabricated by blanking, deep drawing, bending or stamping to a desired shape without affecting the coating. Coated metal requires only reasonable care in handling.

Fabricated and coated parts are diffusion-bonded by heating at 1,700-1,800 F. in a hydrogen or inert atmosphere for about 5 to 15 min. The carrier volatilizes during this exposure and dissipates in the furnace atmosphere. Reasonably good contact of the mating surfaces is required.

Technique can be used to join copper to other metals by use of a coated strip placed between components.

▶ **Some Limitations**—In its present stage, the diffusion-bonding process has certain limitations. After exposure at the diffusion bonding temperature, the base metal is in a fully annealed condition with its characteristic mechanical properties. Some applications may permit subsequent mechanical working, such as coining or internal expansion, to increase hardness and tensile properties.

The diffusion-bonding process is only suitable for some copper alloys, particularly alloys with high copper content. And true diffusion bonds are not possible, at present, with brasses containing more than 5% zinc. Braze joints have worked with brasses (zinc contents up to 30%) but these are not homogeneous bonds—there is a separate metallurgical phase at the bond line.

New T-1 Steel Good As Old, but Cheaper

Significant savings in the fabrication of stronger, lighter steel structures and equipment are promised by a new, low-cost constructional alloy steel developed by U. S. Steel Corp.

Called T-1 Type A steel, the new alloy is available in quenched and tempered plates and bars, ranging from ⅜- to 1-in.-thick, inclusive.

In this thickness range, Type A steel has the same 100,000-psi. minimum yield strength as standard T-1, which was introduced in '53. Also, in thicknesses up to 1 in., the new material and the original T-1 steel have the same toughness, weldability and resistance to impact and abrasion. However, Type A costs significantly less (up to 45%) because of differences in chemical composition.

SILICONE NEWS from Dow Corning

Now...Time for the Boys

Electrical Problems No Longer Short Circuit Our Family Fun

Sure, a father should be a pal to his sons . . . and, mine are at the age when they need and appreciate my companionship most. But when you're lucky enough to be employed at an assembly plant that's doubled capacity twice in the past eight years, you've got more than a full time job . . . and family activities frequently have to take a back seat.

During these eight years I've come up through maintenance to Assistant Plant Manager. It started when I suggested we replace certain troublesome motors with silicone insulated units. Then, when we doubled our plant the first time, I suggested we could double our electrical load capacity in the same floor space by using silicone insulated transformers. Just before our last expansion, my boss was made Plant Manager and I moved up to his assistant. He's taught me a lot . . . and I think I've helped him. We're a good team. And, for the first time since I started working, I'm finding time to really enjoy my boys. By the way, the car we're restoring is a Model A. No, not a Ford . . . a Dusenberg.

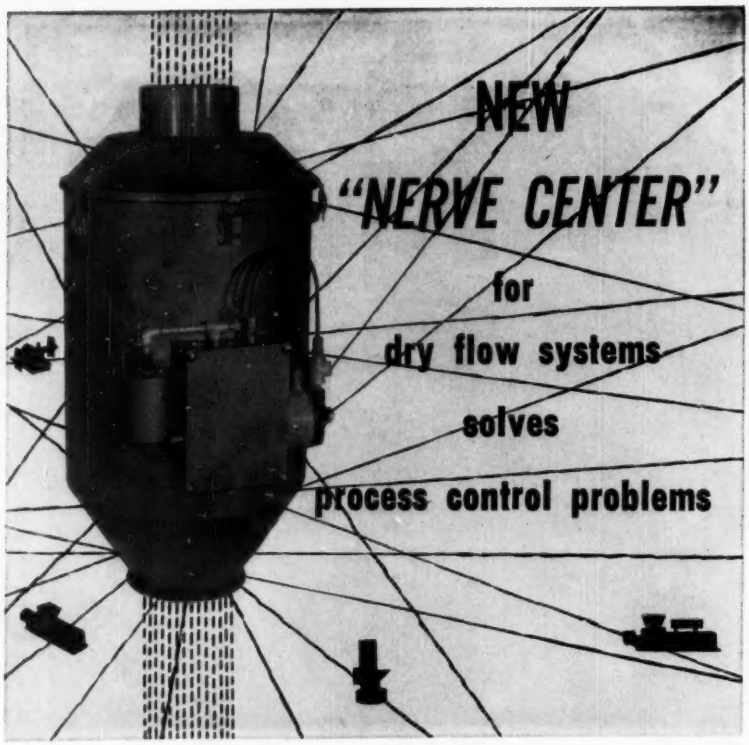
I think my progress is the result of plenty of hard work and a good eye for new and better ways of doing things. One of the most important things I've ever read was an advertisement on Dow Corning silicone insulation for electrical transformers and motors—just as you're doing now. I wrote for more information. Why don't you?

For brochure, "Specify Silicone Insulation and Save", Write Dept. 1815.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.



The new W&T Massometer® senses flow in closed systems. It measures dry, free-flowing materials and translates the results into a 3-15 psi signal. The unit can be used to indicate or record. It also controls proportional blending . . . helps solve problems in all kinds of control situations.

And the Massometer does all this without breaks in your closed system. Air-tight construction means a flow-sensing unit that seals dust in . . . seals contamination out. It is compact and easily installed, fits neatly into the line. Stainless steel for parts exposed to the flow stream and dust-tight motor casing assure years of maintenance-free service.

The Massometer is calibrated with any maximum output between 40 and 200 lbs. per minute. Maximum volumetric capacity is 6 cubic feet per minute. Repeatability within ±0.2% of full scale assures stable performance.

By generating a signal proportional to flow, the W&T Massometer brings a new look to ratio control. Its versatility means more accurate batch processing, or helps create continuous processing in new or existing systems.

For information, write Dept. M-50.29.

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CPI NEWS BRIEFS . . .
(Continued from page 78)

the location or capacity of its forthcoming facility, but has projected its annual TEL and TML sales to over $20 million. S.L.O.I. will have an equity in the new operation.

Crown Central Petroleum Corp. will install a Udex unit at its refinery in Houston. Feedstock will come from a catalytic reformer, which is undergoing a 50% expansion in capacity. Unconfirmed information outlines the capacity of the Udex unit as 4 million gal./yr. benzene, 10 million gal./yr. toluene, and 12 million gal./yr. xylenes. Contractor for the project is Tellepsen Construction Co., Houston.

Foremost Food & Chemical Co., Oakland, Calif., subsidiary of Foremost Dairies, Inc., has completed a plant in that city to produce fatty nitrogen chemicals. Designed for a capacity of about 20 million lb./yr., facility is said to be the only manufacturing source for these chemicals west of the Mississippi. Output will be used primarily in flotation of nonferrous ore, and in manufacture of textile softeners, corrosion inhibitors, insecticide intermediates, lubricants, oil additives and other petroleum products.

Eastman Kodak Co. has budgeted $70 million for capital improvements of its U. S. facilities during '61, $30 million of which will go into the firm's Tennessee Eastman and Texas Eastman divisions. No details have been disclosed on the what, when, or where of specific improvements, except that parent company's photographic facilities in Rochester, N. Y., will be expanded and modernized with approximately $34 million of the total capital.

General Electric Co.'s Atomic Power Equipment Dept. has expanded and centralized its chemical and metallurgical laboratory at San Jose, Calif., in a move to hasten development of better fuels and materials for nuclear power

plants. Cost of the program: $100,000. This project is in addition to a new chemistry and metallurgy laboratory that the department is erecting at its Vallecitos research center near Pleasanton, Calif.

Columbia University, New York, has bought a self-regulating TRIGA reactor for research use. It has a normal operating power of 10 thermal kw. and is capable of being "pulsed" for fractions of a second to high peak-power levels. Reactor was designed and developed by the General Atomics Div. of General Dynamics Corp.; it will be the first one to be installed and operated in New York City.

Tennessee Gas Transmission Co. will build a multimillion-dollar petrochemical plant in Texas, on the Houston Ship Channel, in connection with a long-term production and marketing association announced between the firm and **Cary Chemicals, Inc.,** East Brunswick, N. J. Construction is to start this year, to be finished in '62. The facility will include a 100-million-lb./yr. acetylene unit that will operate on methane feedstock, and a unit that will convert most of the acetylene into vinyl chloride monomer.

The monomer will be shipped to Cary's facilities in New Jersey, and the company will use it to make vinyl polymers. Company will expand its compounding and calendering facilities for these polymers at East Brunswick.

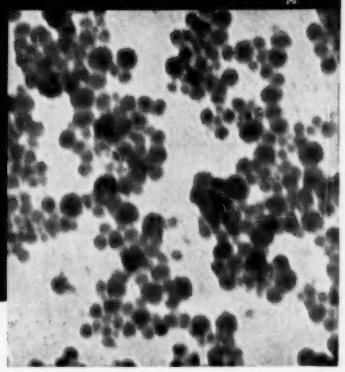
Under the agreement, Cary will continue as an independent, publicity owned corporation, and Tennessee Gas will have substantial interest in it. Cary is expected to have equity participation in the new plant in Texas.

Westinghouse Electric Corp. has added a 50,000-sq. ft. building to the facilities of its semiconductor department at Youngwood, Pa. The new building will be used mainly for development and processing of semiconductor materials, including new forms of silicon and germanium.

Temescal Metallurgical Corp., Berkeley, Calif., is installing a 25-

Nalcoag® 1050
STABLE SILICA SOL
49-50% Silica by Weight

New Colloid Carries Heavy Silica Load, Yet has Low Viscosity, Good Stability



Silica spheres in Nalcoag exhibit a high degree of uniformity, have 20-25 millimicron diameters. *Photo taken by electron microscope in Nalco laboratories. 65,000X.*

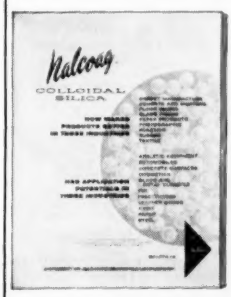
New Nalcoag 1050 is the "compact" model in the Nalco line of colloidal silicas . . . first commercial silica sol to offer you 49-50% silica by weight!

In comparison with the 20% to 35% concentrations now widely used, Nalcoag 1050 gives you up to 60% more silica in every drum . . . effects real savings in storage, handling and transportation costs. And despite its high concentration new 1050 has the high stability and low viscosity so essential to ease in handling and application.

TYPICAL PROPERTIES OF NALCOAG 1050

Percent colloidal silica as SiO_2 49-50	pH . . . . . 9.0±0.1
Average surface area, M^2/gram. . 120-150	Viscosity at 77°F. cps. 20-30
Average particle size, millimicrons 20-25	Specific Gravity at 68°F. 1.385
Density, lbs./gal. at 68°F. 11.6	Na_2O, percent 0.30

BOOKLET SUGGESTS PROFITABLE USES FOR Nalcoag



And these are many! Nalco Bulletin K5 will explain the various ways in which Nalcoag can improve such products as:

Paper Containers — **Textiles**
Floor Waxes — **Foam Rubber**
Cements & Mortars — **and many others.**

Write for your copy today. And if you would like a sample of new Nalcoag 1050, be sure to tell us. We will be glad to send that, too.

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Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany
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. . . Serving Industry through Practical Applied Science

Nalco CHEMICALS

DENVER Equipment

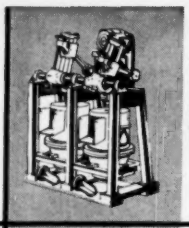
FOR THE CHEMICAL PROCESS INDUSTRY

DENVER AGITATORS AND MIXERS

Agitator types available: Turbine-type propeller (to 120" in tanks to 50' dia.), slow speed, high speed, air lift, vertical turbine mixers, mixer-settler units.

Write for Bulletin No. A2-B2

Lab and pilot scale agitators in LG3-B10



DENVER DIAPHRAGM PUMPS

Stroke can be adjusted while pump is operating. Long wearing nylon-reinforced rubber diaphragm. Sizes 1" to 10" simplex and duplex, capacity to 1000 g.p.m.

Write for Bulletin No. P8-B12

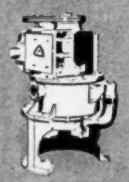
Lab and pilot scale diaphragm pumps in LG3-B10

DENVER ATTRITION SCRUBBERS

High power input to efficiently remove sand coatings, mix dense slurries. Rubber lined or acid-proof tanks. Sizes to 56"x 56"

Write for Bulletin No. A-8505

Lab and pilot scale scrubbers in LG3-B10

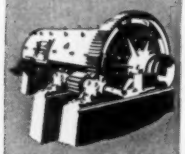


DENVER VERTICAL CENTRIFUGAL PUMPS

For handling frothy liquids or coarse, sandy slurries, constant or intermittent flow. No packing gland or sealing water. Standard or stainless steel construction. Capacity to 450 g.p.m.

Write for Bulletin No. P10-B5

Lab and pilot scale vertical centrifugal pumps in LG3-B10



DENVER BALL AND ROD MILLS

Offer operation and convertibility. Wet or dry grinding systems. All steel construction. Ceramic or rubber linings available. Sizes to 10'x 20'.

Write for Bulletin No. B2-B20

Lab and pilot scale mills in LG3-B10

DENVER SRL (RUBBER LINED) PUMPS

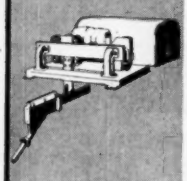
High efficiency, low horsepower. Parts last longer, cost less. Rubber lined. PUMPS AND PARTS IN STOCK. Sizes to 5000 g.p.m. Now available in "TRU-GLANDLESS" construction. No sealing water. No packing glands. No slurry dilution. **Bulletin P9-B28.**

DENVER JAW CRUSHERS

Cast steel frame, anti-friction side bearings and bumper bearings. Manganese steel jaw and cheek plates. Sizes from 2¼"x 3½" to 36"x 48".

Write for Bulletin No. C12-B12

Lab and pilot scale crushers in LG3-B10

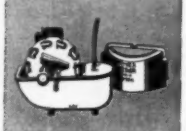


DENVER SAMPLERS

Continuous mechanical and automatic types for dry, solution or slurry sampling. Complete sampling plants and sample processing equipment. SAMPLERS IN STOCK.

Write for Bulletin No. S1-B4

Lab and pilot scale samplers in LG3-B10

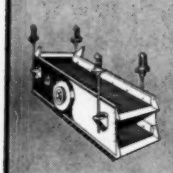


DENVER REAGENT FEEDERS

Both wet and dry feeders available. Let us know your requirements. Many standard units in stock.

Write for Bulletin No. F6-B8

Lab and pilot scale feeders in LG3-B10

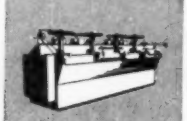


DENVER-DILLON SCREENS

For efficient wet or dry screening. "True-Circle" eccentric action. Sizes to 6'x 14' in stock. Also Trommel Screens in sizes from 30"x 60"x 120".

Write for Bulletin No. S3-B15

Lab and pilot scale screens in LG3-B10

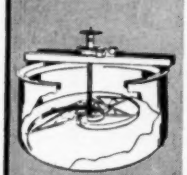


DENVER "SUB-A" FLOTATION

Universal tank with three types of mechanisms: (a) "Cell-to-Cell"; (b) "Free-Flow"; (c) Type "M". Sizes from 16"x 16" to 72"x 72".

Write for Bulletin No. F10-B86

Lab and pilot scale flotation in LG3-B10



DENVER SPIRAL RAKE THICKENERS

Move settled materials to center in one revolution. Simple, efficient, heavy-duty gear mechanism for thickeners to 150' dia. Acid proof construction available.

Write for Bulletin No. T5-B6

Lab & pilot scale thickeners in LG3-B10

SEE OUR CATALOG ON PAGES 949-956 IN C.E.C.

DENVER EQUIPMENT COMPANY

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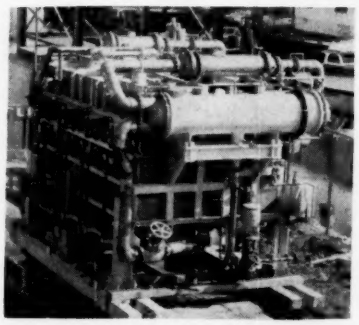
DENVER TESTING FACILITIES

You will have problems in crushing, grinding, settling and possibly concentration and filtering. These are our specialties so please let us help you in our Test Department. Deco flowsheets are reliable and proven.

CPI NEWS BRIEFS . . .

ton electron beam furnace at the firm's new plantsite in that city. Facility will be about three stories high, and is said to be the largest of its type ever built. It will permit Temescal to augment its product line with refractory metals such as tungsten, zirconium and titanium, as well as cobalt and nickel alloys and specialty steels.

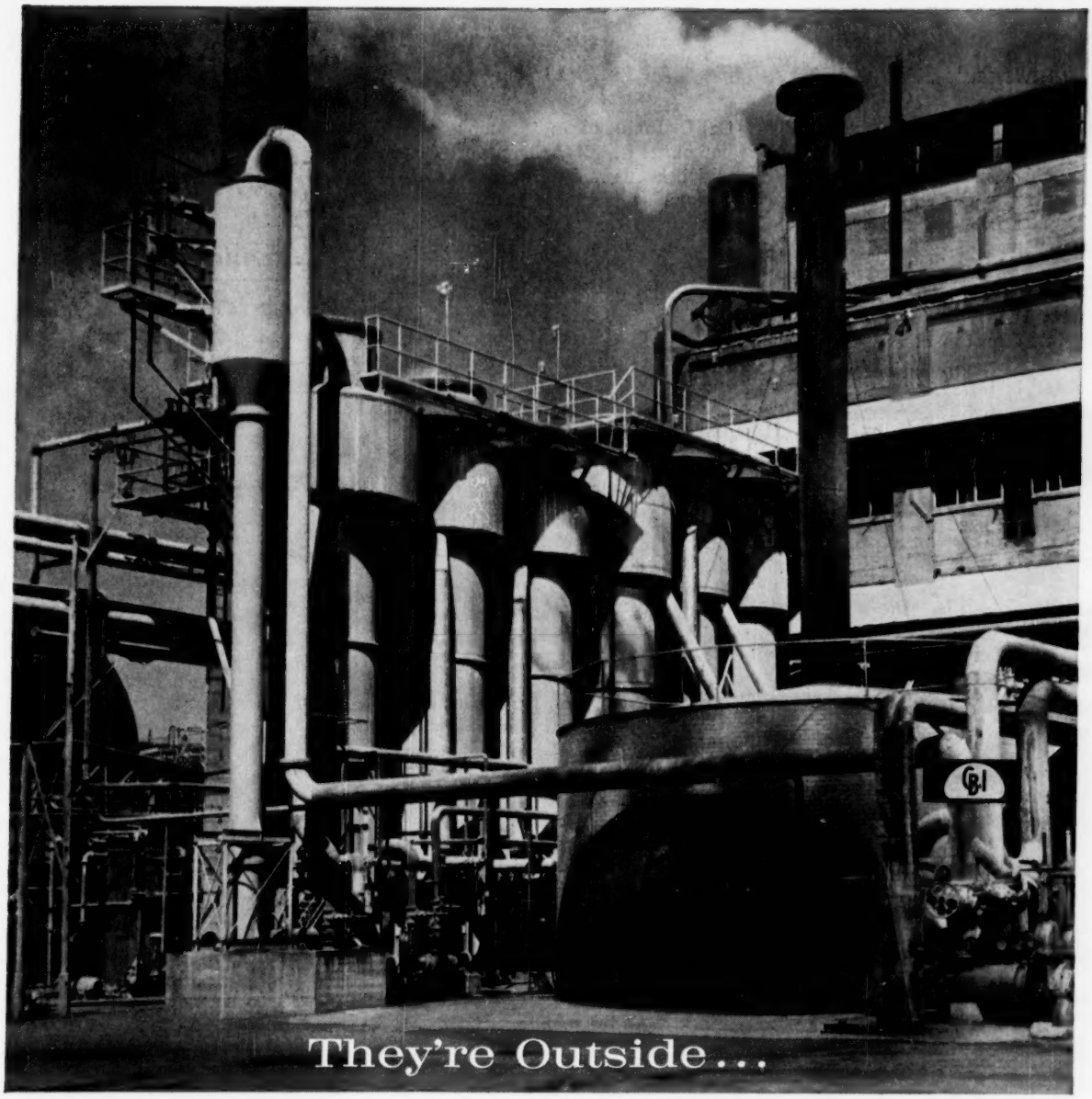
The company recently moved its offices and plant to Berkeley from Richmond, Calif.



Badger Mfg. Co., Cambridge, Mass., is building six 50,000-gal./day sea water distillation plants of improved design for the Navy. Units, one of which is pictured above, use four stages of low-temperature flash evaporation; they are described as being some 20% lighter and 50% smaller than older flash distillation plants of equivalent capacity.

Merck & Co.'s Merck Chemical Div. is spending approximately $2 million at its Elkton, Va., plant to install facilities for commercial production of a new drug called AmProl. Developed to fight coccidiosis, a poultry disease, the drug recently sparked a $7.8-million proprietary-information lawsuit involving R. S. Aries & Associates, Chimel S. A. of Switzerland, and French firm Synorga (*Chem. Eng.*, Aug. 22, '60, p. 45).

Westinghouse Electric Corp. has tripled the size of its East Pittsburgh, Pa., data-processing center. The multimillion-dollar expansion program included installation of an IBM 7090 and two IBM 1401 computers, a Remington Rand Univac, and three analog



CB-6110

Require Minimum Space...
Need No External Support...

Installation of CB&I's sextuple effect evaporator at International Paper Company's Georgetown, South Carolina, mill resulted in the following performance:

More than 99.9% of the chemicals processed by this evaporator are recovered. Equally important are the operating economies of this highly-efficient evaporator system. Waste heat is collected at a low cost.

The CB&I patented integral preheaters reduce steam requirements and improve the evaporation capacity. The patented entrainment separators for recovering process chemicals are most efficient.

Constructed with stainless steel and Hortonclad® stainless in areas subject to corrosion, and embodying CB&I's high standards of fabrication, this evaporator will operate efficiently for years with minimum maintenance costs.

This evaporator is one of many ways CB&I works with the pulp and paper industry in improving efficiency and increasing production. Chicago Bridge & Iron Company, 332 South Michigan Ave., Chicago 4, Illinois. Offices and subsidiaries throughout the world.

CB&I

computers for simulation of electrical systems. Expanded facility is said to be one of the first in the country to combine scientific and commercial work in one integrated program.

Texaco Inc. has begun operating a new IBM 7090 computer at the firm's Houston office. The $4-million unit replaced an IBM 705 computer, installed in March '57, which the company had been operating virtually around the clock for more than a year.

Offices

General Mills, Inc.'s Chemical Div. has opened a new district sales office at Houston. It will handle sales of the division's line of resins, surfactants and fatty nitrogen chemicals.

Thompson Ramo Wooldridge Inc. is consolidating nearly 200 of its people from various offices in the Los Angeles area to the company's headquarters at Canoga Park, Calif. Included in the move are personnel of TRW Computers Co., which is the marketing and applications engineering organization for the firm's RW-300 Process Control Computer. Up to now, this organization has been located at Beverly Hills.

Tuloma Gas Products Co., Tulsa, Okla., has opened a new district office at Wood River, Ill. Company also reports that construction is under way on a 150,000-bbl., underground storage terminal at Wood River, which will be used to store propane piped from a nearby refinery of American Oil Co.

Sprout, Waldron & Co., Inc., has established an office in San Antonio, Tex., to direct the firm's sales programs in Latin America.

Kaiser Aluminum & Chemical Corp.'s Kaiser Refractories & Chemicals Div. has established a new distribution facility at Springville, Calif. It will handle the division's full line of fire clay specialty products and basic refractories.

Parke, Davis & Co. goes modern with branch office

This graceful layout is Parke, Davis & Co.'s new branch office and warehouse for the metropolitan Los Angeles area. Cylindrical office building in foreground and warehouse in rear cost a total of $600,000. Architecture was by Charles Luckman & Associates, Los Angeles, and general contractor for the project was Ruane Co., Los Angeles.

ANOTHER NEW ACHIEVEMENT IN MODERN FLOW CONTROL BY CRANE

1 Single retaining nut holds cartridge assembly in body, for fast, foolproof dismantling and assembly

2 Teflon* thrust washer reduces stem friction; absorbs line pressure load on ball

3 Teflon* seats pre-loaded for tight shut-off with minimum torque

4 Bright plastic grip insulates handle and flags valve position

5 Positive, Standard Size O-ring seals on stem, cartridge

6 Self-aligning, precision-machined ball, polished and chrome-plated to minimize friction and wear on seats.

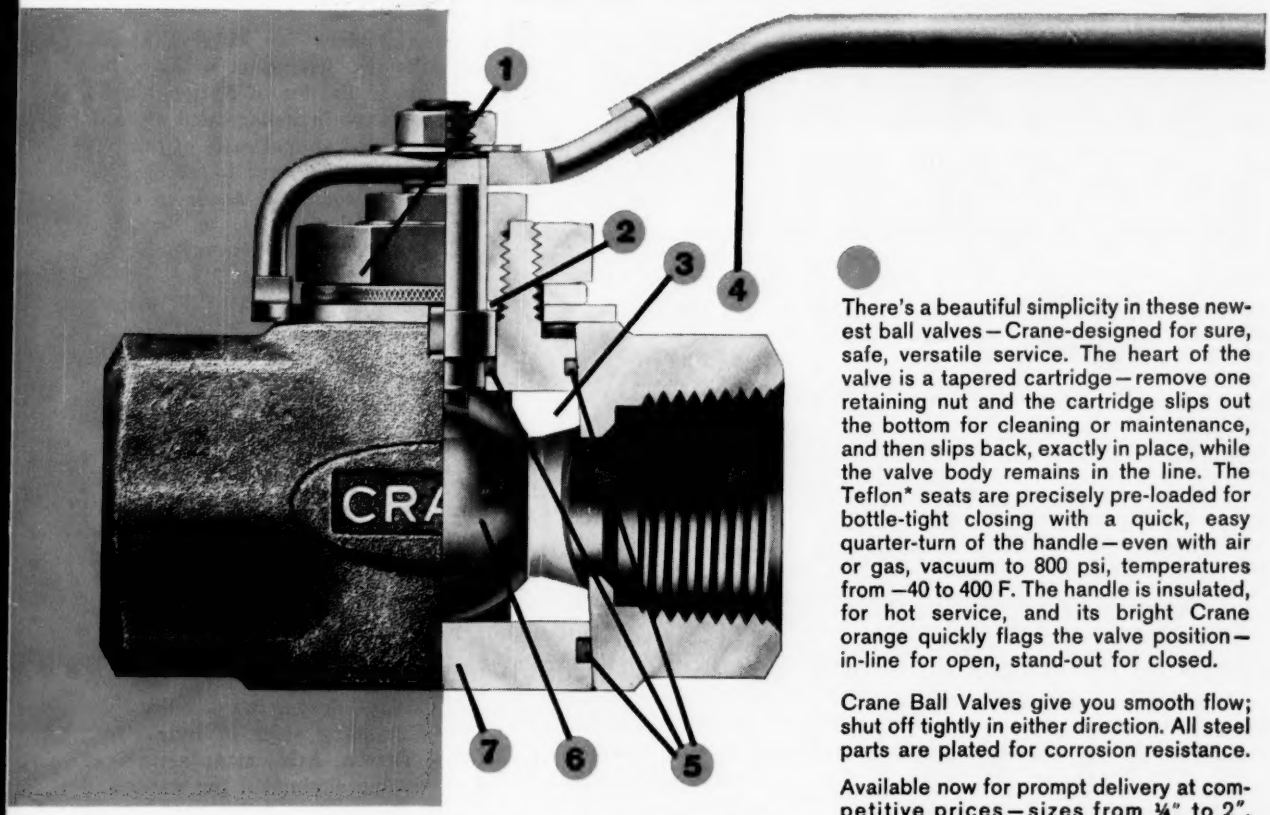
7 Tapered cartridge contains all working parts; slips out bottom in one piece for cleaning or maintenance

* Teflon is a registered trademark of E.I. DuPont de Nemours & Co., Inc.

CRANE BALL VALVES

with the exclusive tapered cartridge that drops out for fast, in-line servicing

engineered for corrosion resistance plus tight shutoff



There's a beautiful simplicity in these newest ball valves—Crane-designed for sure, safe, versatile service. The heart of the valve is a tapered cartridge—remove one retaining nut and the cartridge slips out the bottom for cleaning or maintenance, and then slips back, exactly in place, while the valve body remains in the line. The Teflon* seats are precisely pre-loaded for bottle-tight closing with a quick, easy quarter-turn of the handle—even with air or gas, vacuum to 800 psi, temperatures from −40 to 400 F. The handle is insulated, for hot service, and its bright Crane orange quickly flags the valve position—in-line for open, stand-out for closed.

Crane Ball Valves give you smooth flow; shut off tightly in either direction. All steel parts are plated for corrosion resistance.

Available now for prompt delivery at competitive prices—sizes from ¼" to 2", screwed ends, in bronze, steel and Type 316 stainless.

Call your Crane Distributor or send today for a complete, illustrated folder on the outstanding new Crane Ball Valves, engineered for unmatched service.

CRANE

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4100 South Kedzie Ave., Chicago 32, Ill.

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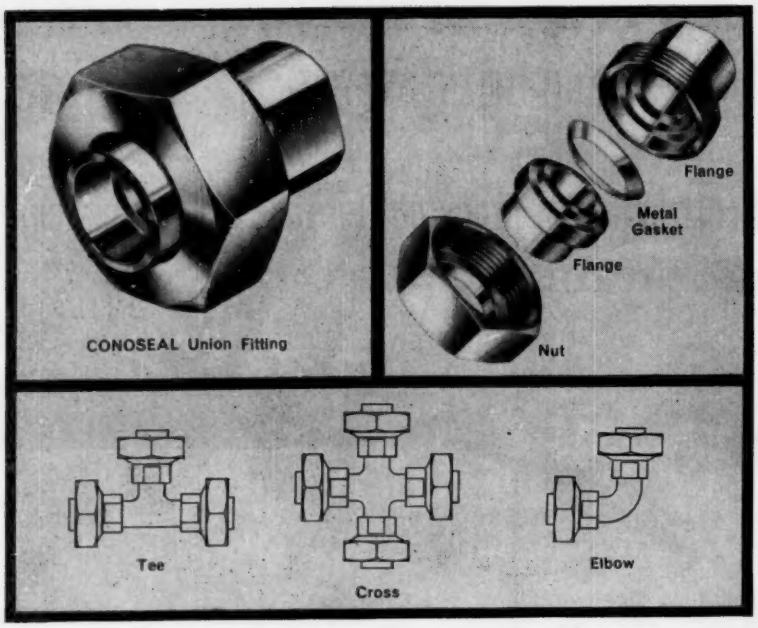
Valves/Electronic Controls/Piping/Plumbing/Heating/Air Conditioning



Use MARMAN CONOSEAL Union Fittings for highest performance when joining all types of small diameter tubing

Now you can get highest performance that will solve any tube joining problem, with the new Marman CONOSEAL Union Fitting. And you also realize savings in materials, installation and maintenance over conventional joining methods.

The new CONOSEAL Union Fitting assures a dependable leak-proof seal with working pressures of 4000 psi and burst pressures of 16000 psi at room temperatures. Temperature capabilities range from −450°F. to +1500°F. O. D. tube sizes available from ⅛" through 1", with a full range of tees, crosses and elbows. Let the CONOSEAL Union Fitting meet your specifications for a wide variety of applications, including connection of dissimilar metals. Other benefits? CONOSEAL Union Fittings are compact, lightweight and require no periodic retorquing.

Get full information about the new Marman CONOSEAL Union Fitting. Ask your Marman Field Engineer, or write for a copy of our Bulletin 804.

CONOSEAL is an Aeroquip trademark

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CPI NEWS BRIEFS . . .

Companies

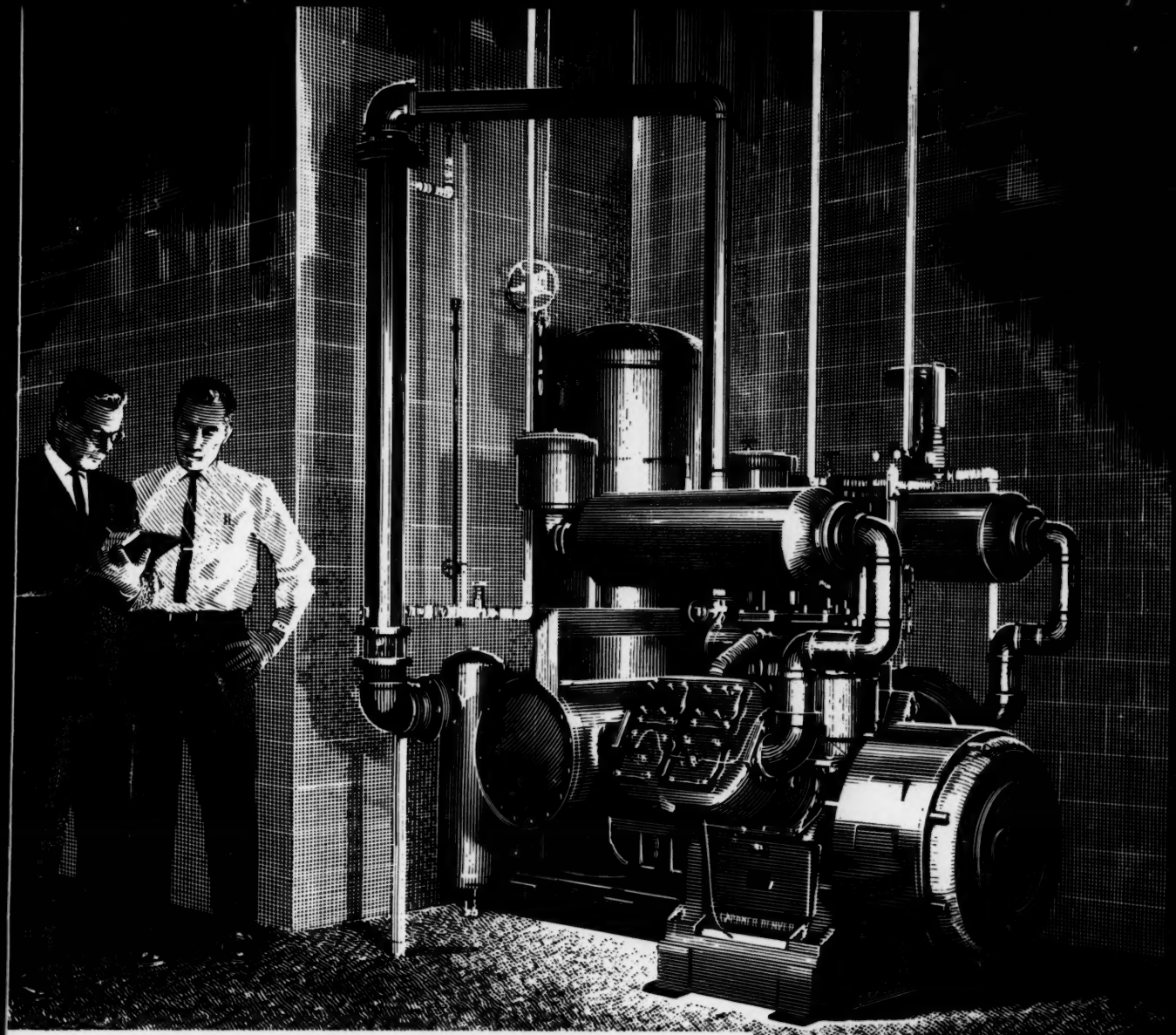
National Distillers & Chemical Corp., New York, and Bridgeport Brass Co., Bridgeport, Conn., appear headed for a merger, with the former to be the surviving company. Boards of directors of both firms have approved the merger in principle; final details are being worked out for presentation to stockholders in May. Proposal calls for Bridgeport Brass to become a division of National, with no change in management or staff. Combined annual sales of the two companies amount to about $730 million, combined assets to about $625 million.

National has also acquired a dry-fertilizers plant at Whitewater, Wis., from Wisconsin Farmco Service Cooperative. It will be operated by National's mixed-fertilizer division, the Federal Chemical Co.

Lone Star Aluminum Co. is a new firm that has been organized in Corpus Christi, Tex., to make aluminum sheet and foil products. When the company starts production, it will constitute the state's only aluminum sheet rolling operation.

General American Transportation Corp., Chicago, has acquired the outstanding stock of Infilco Inc., a Tucson, Ariz., manufacturer of treating equipment for water and liquid wastes. Infilco has manufacturing plants at Chicago and Salem, Ill., a small foundry at Joliet, Ill., and sales, engineering and research divisions at Tucson. It will continue to operate under its present management, in connection with General American's Fuller Co. subsidiary.

Consolidated Aluminum Corp., a Jackson, Tenn., producer of aluminum foil, coiled sheet and "super purity" (99.992% minimum) aluminum, has acquired AIAG Metals, Inc., New York. Through this acquisition, Consolidated becomes the sole U. S. distributor of high-purity gallium and aluminum produced by processes of Aluminum



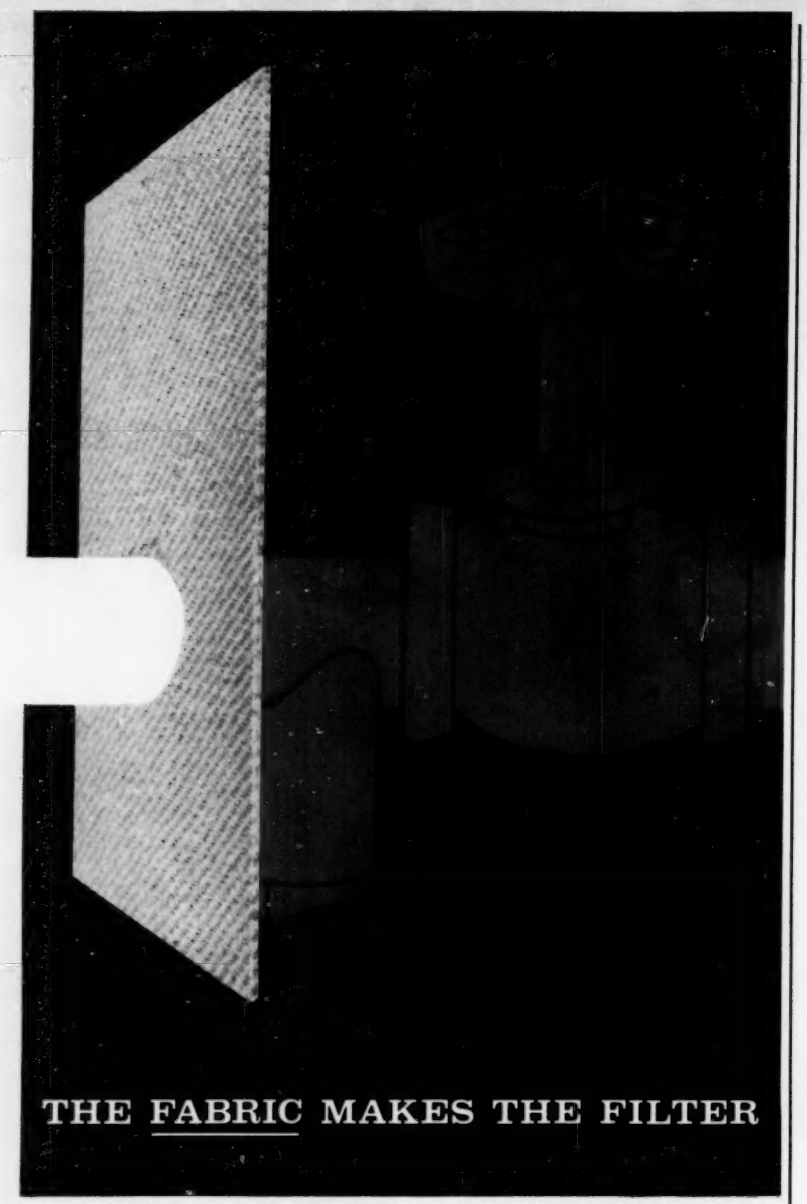
"We pocket the difference"

The difference? Saving in floor space. No foundation cost. Quick and easy installation. The Gardner-Denver packaged air compressor goes right to work . . . provides a dependable supply of air for years. Want details? Request Bulletin WB-10.

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd.,
14 Curity Ave., Toronto 16, Ontario

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER - DENVER



And that's why so much time and effort go into the manufacture of U.S. Royal Filter Fabrics—why the depth and breadth of U.S. Royal textile experience is so important to you. "U.S." fabrics combine efficient filtration with maximum resistance to heat, chemicals and abrasion. Cake retention-and-discharge properties are excellent. Special weaves and blends of natural and synthetic fibers meet the most specialized filter needs. Through independent research, painstaking development and carefully controlled production, our textile engineers continually seek new ways to make fibers and fabrics serve you better. To find the filter fabric that can serve your operations best, contact our Industrial Textiles Department at the following sales offices:

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Textile Division
United States Rubber

Industrie AG, of Switzerland. Gallium has grown in commercial importance during recent years because some of its compounds have widespread use in semiconductors.

Dixon Chemical & Research, Inc., Bloomfield, N. J., has contracted to buy all the capital stock of Better Finishes & Coatings Co. and its subsidiaries. Based in Newark, N. J., the latter firm produces specialty coatings, sealing compounds and chromic acid. Purchase price: $750,000, which will be paid in both cash and stock.

The Glidden Co., Cleveland, has bought the assets of the metals division of The Crane Co. Products of the newly acquired division, which has its facilities at Johnstown, Pa., include electrolytic and reduced iron powder, and electrolytic vacuum melting stock; these will round out Glidden's own line of metal powder products.

Brush Beryllium Corp., Cleveland, has acquired a 29½% interest in Beryllium Resources, Inc., a Western firm that has claims to beryllium ores in Utah's Topaz Mountain area. Beryllium Resources was formerly owned by Federal Resources Corp. and Hidden Splendor Mining Co., both of Salt Lake City, Utah; now, each of these firm's ownerships also amounts to 29½%, and the remaining interest is held by a Los Angeles engineer. According to Beryllium Resources executives, Brush will develop a mine and mill program this year at Topaz Mountain.

International

Yugoslavia: A $35-million petrochemical complex to make polyethylene, styrene, polystyrene, phenol and acetone is being built at Zagreb for Organsko Kemijska Industrija. It will include eight processing units plus offsite facilities. Investment funds are being provided by the U. S. Development Loan Fund and other financial interests in England and Yugoslavia. Detailed mechanical engineering

and supervision of construction will be by Foster Wheeler Corp., New York.

West Germany: Chemische Werke Huels AG (Marl) and Tennessee Eastman Co., Kingsport, Tenn., are forming a joint subsidiary, Faserwerke Huels GmbH., which will build a polyester-fiber plant at Marl. Unconfirmed reports indicate that capacity will be 6,000 tons/yr., required investment about $10 million.

Peru: Corporacion de Reconstruccion y Fomente, Cuzco, has obtained government approval to build a 62,000-metric ton/yr. ammonium nitrate plant. Output will be sufficient to meet fertilizer requirements for one third of the cultivated land in the southern part of the country. Estimated cost of the plant: $10 million.

England: Distillers Co. Ltd. has made a $36.5-million share-exchange offer for British Xylonite Co. Ltd., described as one of the largest British fabricators of plastics. Distillers already holds 50% interest in British Xylonite's subsidiary, B. X. Plastics, which is the source of more than half its parent firm's profits. Under the proposed acquisition, British Xylonite would maintain its own identity.

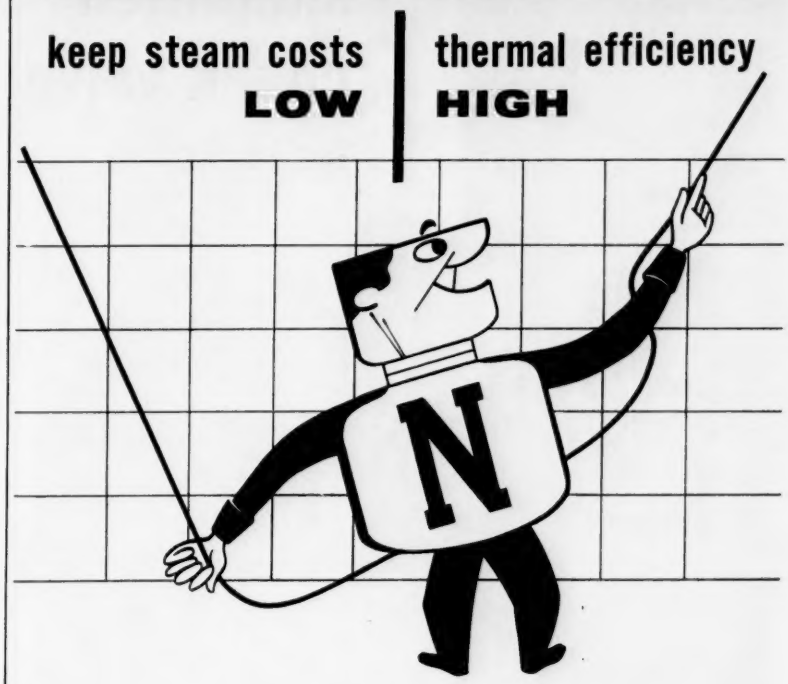
Canada: B. C. Forest Products Ltd. plans to build a $25-million newsprint mill at Crofton, B. C., adjacent to a pulp mill that the firm operates. Construction is expected to start this year, and the plant is scheduled to be in operation by 1964. It will have daily capacity of 350 tons.

England: Imperial Chemical Industries Ltd. will spend over $11.2 million to improve the research, production and distribution facilities of its Pharmaceuticals Div. The firm is negotiating to buy a site at MacClesfield, Cheshire, where it plans to build a pharmaceuticals factory.

Canada: Imperial Oil Ltd. will build a 30-million-gal./yr. benzene

Nicholson Thermostatic Steam Traps

keep steam costs LOW | thermal efficiency HIGH



Low costs and high efficiency! Nicholson Traps give you both . . . by *design*. And here's how. Hardened stainless steel seats and valves are accurately lapped for sure, tight shut-off . . . so, there is no waste of live steam. True balanced pressure . . . the operating principle of these valves . . . assures fast intermittent discharge of condensate and air, resulting in maximum thermal value from every pound of steam produced.

As for capacity, these traps *really* have it . . . up to six times greater than ordinary traps. Maintenance? Practically none, for there is only one moving part. No links no pins. No pivots or levers. No adjustable orifices to stick or clog.

Sure, some traps cost less than Nicholson . . . but the 'savings' exist only on the invoice. In actual use, some other traps can cost you three or four times their price in annual steam waste. Be sure to weigh cost against value when *you* buy steam traps. Specify Nicholson Thermostatic Steam Traps on your lines and equipment.

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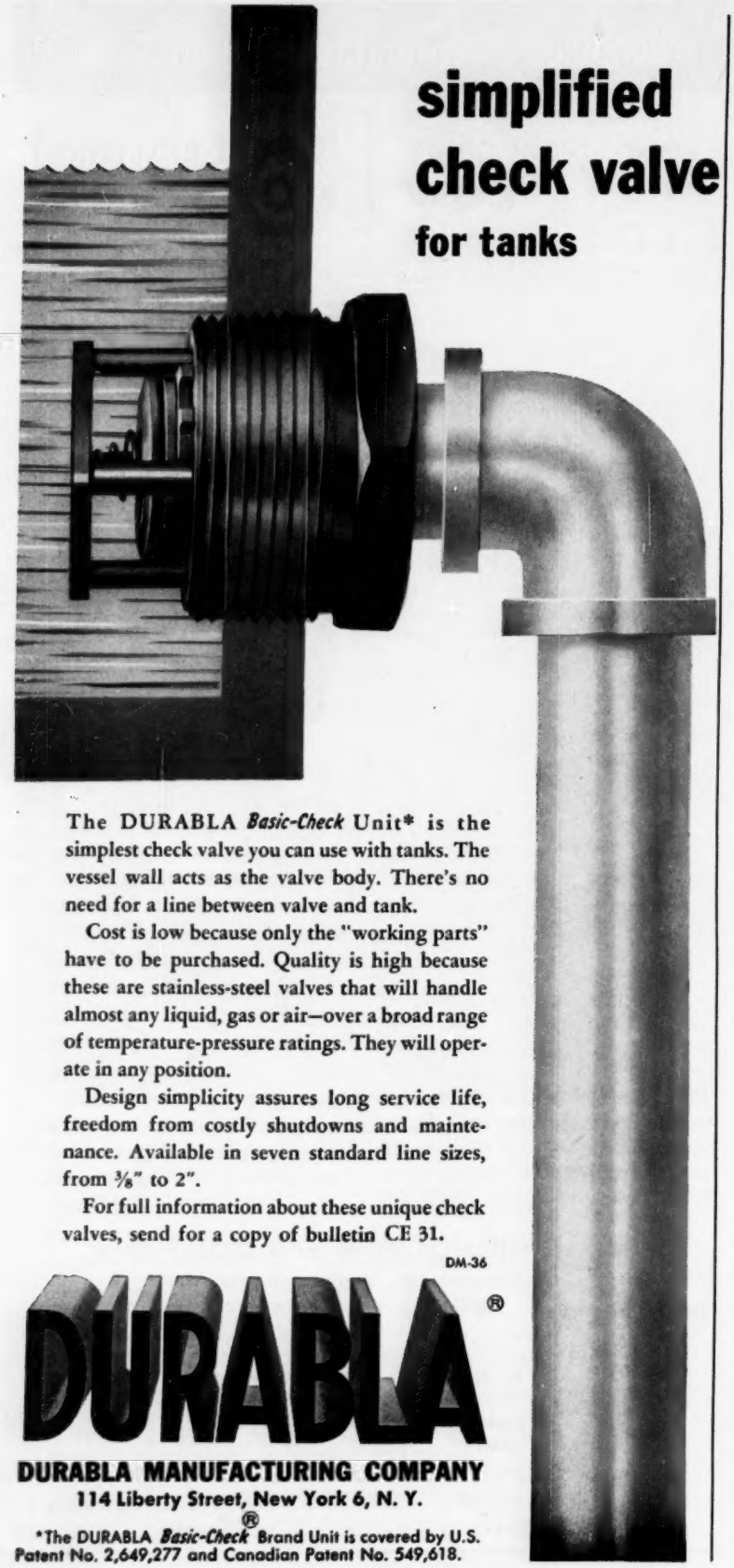

simplified check valve for tanks

The DURABLA *Basic-Check* Unit* is the simplest check valve you can use with tanks. The vessel wall acts as the valve body. There's no need for a line between valve and tank.

Cost is low because only the "working parts" have to be purchased. Quality is high because these are stainless-steel valves that will handle almost any liquid, gas or air—over a broad range of temperature-pressure ratings. They will operate in any position.

Design simplicity assures long service life, freedom from costly shutdowns and maintenance. Available in seven standard line sizes, from ⅜" to 2".

For full information about these unique check valves, send for a copy of bulletin CE 31.

DM-36

DURABLA®

DURABLA MANUFACTURING COMPANY
114 Liberty Street, New York 6, N. Y.

*The DURABLA *Basic-Check*® Brand Unit is covered by U.S. Patent No. 2,649,277 and Canadian Patent No. 549,618.

CPI NEWS BRIEFS . . .

plant at its Sarnia, Ont., refinery. It will cost about $5 million, is described as the country's largest benzene facility. Construction will start this spring and the unit is scheduled to be completed in the fall. Main contract has been awarded to Canadian Bechtel Ltd.

Japan: AviSun Corp., Philadelphia, has concluded an agreement with Tokyo's Shin Nippon Chisso Hiryo, K.K., for the manufacture and marketing of polypropylene resin, film and fiber in Japan. A 30-million-lb./yr. plant will be constructed in that country, with completion scheduled for next year.

Canada's government-owned producer of synthetic rubber, Polymer Corp., Ltd., will spend $19 million on new plant this year. Included in this amount is $10 million that was committed last year for a new solution-polymer plant and additions to other units at the firm's Sarnia, Ont., site, and start of a specialty rubber plant at an undisclosed overseas location. The remaining $9 million will be spent on new facilities for making butyl rubber and for improvement of existing facilities.

Venezuela: United Carbon Co., Houston, will build a $3-million carbon black plant in Venezuela's Valencia industrial area. Initial rated capacity will be 20 million lb./yr., and the unit is due to be completed late this year. It will be operated by a new corporation, United Carbon de Venezuela, C.A.

Canada: Consolidated Mining & Smelting Co. announces that it has started production of pig iron at a new, $7.5-million plant at Kimberley, B. C. Iron produced in this 100-ton/day unit is said to be the first production in western Canada from western ore. The plant is also the initial stage of a major, integrated facility for producing iron and steel; when completed, this facility will produce at least 300 tons/day.

France: The Borden Chemical Co., subsidiary of The Borden Co., New York, will in turn form its eleventh

overseas subsidiary, The Borden Chemical Co. (France) S.A., which will construct a thermosetting-resins plant outside Paris. Completion is scheduled for late this year.

Iraq's government oil refinery at Daura, near Baghdad, now includes a newly completed 5,000-bbl./day catalytic reformer for production of 95-octane gasoline. The $4.8-million unit was supplied, installed and tested by Foster Wheeler Ltd.

India: Oil India Co. has awarded a $2.5-million contract to Whessoe Ltd., a British engineering company, for supply and erection of a plant to condition crude oil at Assam. Plant will neutralize the high wax content of crude from wells in the Assam area; it is scheduled for completion by next year.

Sweden: Svenska Esso, affiliate of Standard Oil Co. (N. J.), has purchased patent rights from Italy's Montecatini for production of polypropylene fiber in Sweden. Svenska Esso's forthcoming polypropylene plant will be part of a petrochemical complex to be built at Stenungsund.

Canada's first detinning plant will be built and operated at Hamilton, Ont., by M&T Products of Canada Ltd., subsidiary of Metal & Thermit Corp., New York. The facility is due to be completed before the end of this year and will cost about $1 million; it will use a modern alkaline process in recovering the metal from high-quality tin plate scrap.

Canada: Pan-American Management Ltd. is a new consulting firm, based in Montreal, Que., which offers special business and technical staff services for corporations of medium or small size that are not likely to employ their own specialists. Company provides consultation in marketing, finance, personnel, technical, operations and other fields of business interest.

ACRAGAGE®
SOLID FRONT *Safety* GAGES

Now in full production at Robertshaw with immediate deliveries on stock models!

Our thanks to the many Acragage customers who said the best was worth waiting for . . . and who patiently waited till production could be transferred to our Knoxville plant.

Now the waiting's over, back orders have been filled—and we're guaranteeing *immediate deliveries* from stock on the most popular models of Acragage pressure, vacuum, compound and test gages.

Our design and special-order departments are also in full swing and can assure quick delivery on models made to your own requirements.

Fast delivery also available on Acragage electric and pneumatic transmitters and receivers.

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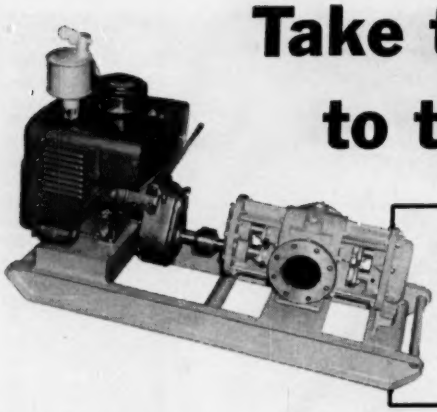
Take the Pump to the Job!



External gear and bearing type GEAREX pump, coupled with speed reducer to gasoline engine and mounted on portable skid-type base for oil gathering in the field.

Pump practically Anything--Anywhere with *Sier-Bath* PORTABLE ROTARY PUMPS

External jacketed GEAREX pump, mounted on fifth-wheel type portable dolly, has 5-hp. gear shift motor drive and push-button starter. Delivers 75 to 15 gpm. of heavy oil base material with viscosities from 10,000 to 300 SSU at temperatures of 120° to 160°F., discharging against 25 to 35 psig. with flooded suction.

- Motor-driven or engine-driven
- Skid-mounted or dolly-mounted
- Wide range of gear and screw pumps to handle materials at
  - —volumes from 1 to 2,600 gpm.
  - —viscosities from 32 to 5,000,000 SSU
  - —pressures to 1,000 psig.

When you need a portable pump for field service—for remote locations—for auxiliary or standby service around the plant, you can have the outstanding performance of Sier-Bath Rotary Pumps with the exact construction, capacity and portable mounting to suit your needs.

Sier-Bath Rotary Pumps handle a wide range of materials whether lubricating or non-lubricating, thick or thin, hot or cold, corrosive or non-corrosive. Compact and rugged—smooth, pulseless discharge—years of dependable pumping with negligible maintenance and repair.

Send us details of any portable pump requirements or discuss your needs with the Sier-Bath representative listed in your "Yellow Pages". Write for catalogs showing all Sier-Bath Rotary Pumps.

Sier-Bath **GEAR & PUMP CO., Inc.**
9259 Hudson Blvd., North Bergen, N. J.
Founded 1905 Member A.G.M.A.

Sier-Bath ROTARY PUMPS

Convention Calendar

March

5-9. The American Society of Mechanical Engineers and The U. S. Department of Defense, 6th Annual Gas Turbine Conference and Products Show, Shoreham Hotel and Pentagon, Washington, D. C.

7-9. The Material Handling Institute, The Industrial Truck Assoc., Spring Meeting, Sheraton Blackstone Hotel, Chicago, Ill.

13-17. National Assn. of Corrosion Engineers, Annual Conference & Corrosion Show, Statler Hotel, Buffalo, N. Y.

15. Society of Plastics Engineers and American Society of Tool and Manufacturing Engineers, "Plastics for Tooling", Statler-Hilton Hotel, Detroit, Mich.

15-17. Natural Gasoline Assn. of America, 40th Annual Convention, Baker Hotel, Dallas, Tex.

16-17. American Society of Mechanical Engineers, Textile Engineering Conference, Clemson College, Clemson, S. C.

17-18. Technical Assn. of the Pulp and Paper Industry, American Society for Quality Control, Chemical Div., Course in Evolutionary Operation, Dinkler-Plaza Hotel, Atlanta, Ga.

20-24. American Society of Metals, 12th Western Metal Congress, Ambassadore Hotel, and Western Metal Exposition, Pan-Pacific Auditorium, Los Angeles, Calif.

20-31. Purdue University, 9th Annual Industrial Packaging Course, LaFayette, Ind.

21-30. American Chemical Society, National Meeting, Kiel Auditorium, St. Louis, Mo.

21-23. Illinois Institute of Technology and American Society of Mechanical Engineers, American Power Conference, Sherman Hotel, Chicago, Ill.

27-31. Instrument Society of America, Symposium on Temperature, Its Measurement and Control in Science and Industry, Veteran's Memorial Hall and Deshler-Hilton Hotel, Columbus, Ohio.

April

5-7. Institute of Environmental Sciences, 1961 Annual Meeting and Equipment Exposition, Sheraton Park Hotel, Washington, D. C.

5-7. Department of Health, Education and Welfare, Public Health Service, Robert A. Taft Sanitary Engineering Center, Symposium on Ground Water Contamination, Sheraton-Gibson Hotel, Cincinnati, Ohio.

6-7. American Society of Mechanical Engineers, Management Engineering Conference, Statler-Hilton Hotel, New York, N. Y.

9-13. American Society of Mechanical Engineers, Oil & Gas Power Conference and Exhibit, Jung Hotel, New Orleans, La.

10-11. American Institute of Electrical Engineers, Rubber and Plastics Industries Conference, Sheraton Hotel, Akron, Ohio

10-11. American Society of Mechanical Engineers, Maintenance & Plant Engineering Conference, Bancroft Hotel, Worcester, Mass.

10-11. The Combustion Institute, Western States Section, 1961 Spring Meeting, Aeronutronic, Newport Beach, Calif.

10-12. Western Petroleum Refiners Assn., 49th Annual Meeting, Grenada Hotel, San Antonio, Tex.

10-13. American Management Assn., National Packaging Exposition, McCormack Place, Chicago, Ill.

11-12. American Institute of Electrical Engineers, Materials Handling Conference, Pick-Congress Hotel, Chicago, Ill.

11-13. American Society of Lubrication Engineers, Annual Meeting & Exhibit, Bellevue-Stratford Hotel, Philadelphia, Pa.

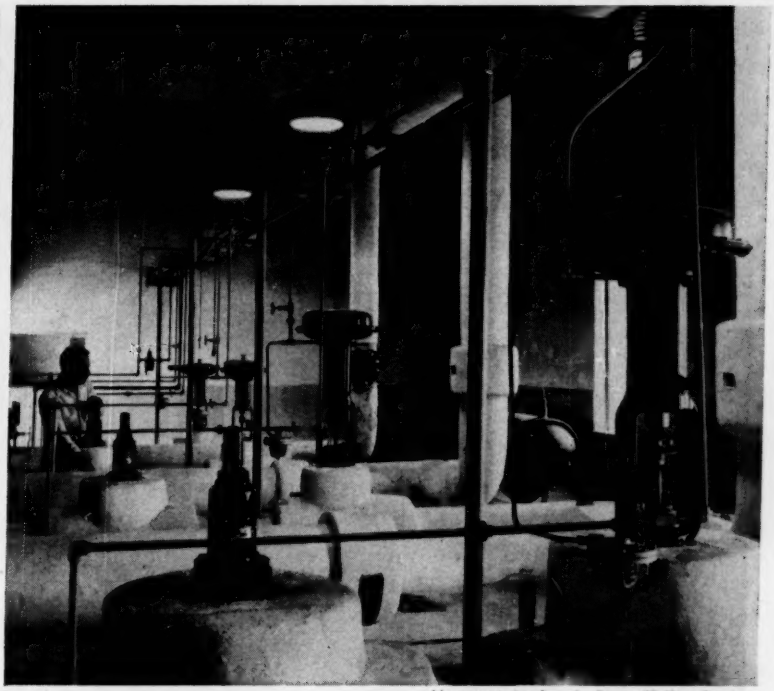
12-14. American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., International Symposium on Agglomeration, Sheraton Hotel, Philadelphia, Pa.

17-19. Instrument Society of America, 7th National Symposium on Instrumental Methods of Analysis, Shamrock-Hilton Hotel, Houston, Tex.

17-19. Purdue University, Conference on Manufacturing Automation, Lafayette, Ind.

18-20. National Institute for Disaster Mobilization, Industrial Mutual Aid & Disaster Control Seminar, Shamrock-Hilton Hotel, Houston, Texas.

18-20. American Welding Society, Annual Welding Exposition, Coliseum, New York, N. Y.

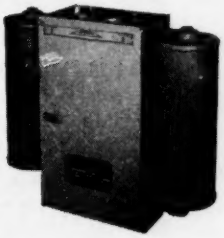


Air-operated valves in Curry Hollow Station.

Lectrodryer eliminates moisture... ends weekly valve maintenance at Carnegie Gas Blending Station

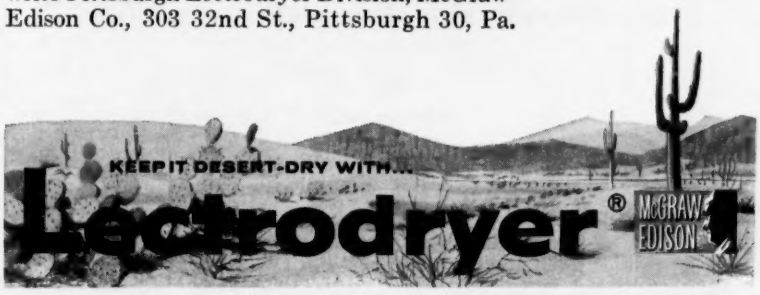
Carnegie Natural Gas Company blends gas from company-owned fields with air to supplement artificial gas produced at the Clairton By-Product Coke Works... then pipes the mixture to all U. S. Steel plants along the Monongahela River. Control of the mixing is handled by valves actuated by compressed air, which is kept desert-dry with a Budget Lectrodryer.

Prior to installation of this dryer, valves had to be drained of water every week. But now, bleeding the air lines—a time-consuming operation—has been completely eliminated. Valves function perfectly.

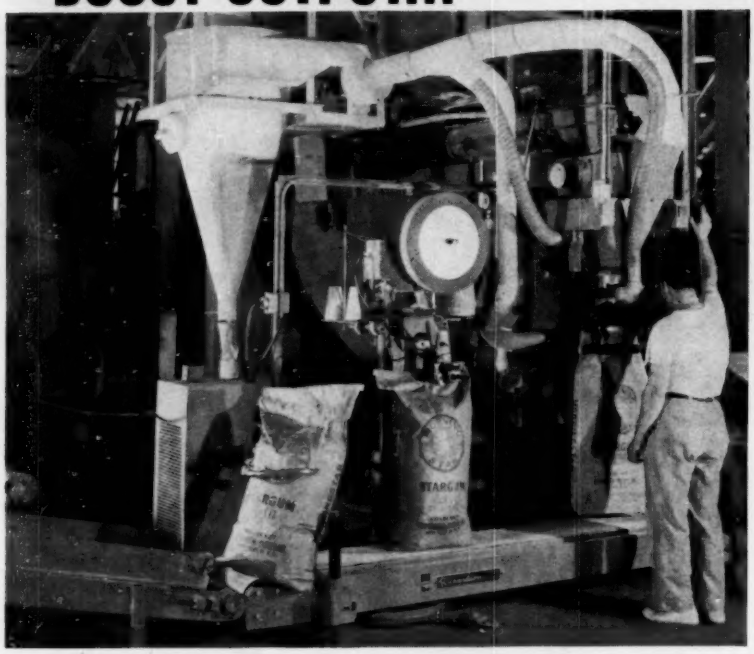


Budget Lectrodryer unit is portable, easy to install.

Budget Lectrodryers are inexpensive insurance (cost only $480 F.O.B. Pittsburgh) against damaging moisture; ideal for any installation requiring small quantities of dry air. For data sheets citing solutions to moisture problems, write Pittsburgh Lectrodryer Division, McGraw-Edison Co., 303 32nd St., Pittsburgh 30, Pa.



HOW MORNINGSTAR-PAISLEY, INC. STOP COSTLY GIVEAWAY, BOOST OUTPUT...



WITH RICHARDSON AUTOMATIC SCALES

Cost-conscious Morningstar-Paisley management is always alert to plugging up wasteful material leaks . . . which explains why they replaced manual bagging with a Richardson Automatic Bagging System. Manual bagging left the door open for costly giveaway of their valuable gums and starch adhesives when the bags were overweight . . . or loss of good will when underweight. It was slow, too. Their Richardson system insures accurate weights automatically, and increases their output per man by giving them a *complete materials handling system.*

This Richardson bin-to-bag system includes a screw feeder, an automatic gross weigher, a bag conveyor, and a sewing pedestal. Now the operator simply slips a bag on the spout and presses the "START" button . . . no lifting of filled bags.

Richardson can stop *your* costly giveaway and boost *your* output, too. Why not phone or write **Richardson Scale Company, Clifton, N. J.**

Send for free technical bulletin

RS-14

Sales and service Branches in Principal Cities. Also manufactured in England, France and Australia. Richardson Scales conform to U. S. Weights and Measures H-44 for your protection.

Richardson

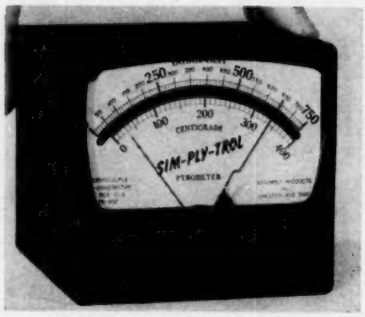
MATERIALS HANDLING BY WEIGHT SINCE 1902

NEW EQUIPMENT . . .

(Continued from page 88)

justment are all said to be accomplished in minutes.

Bold-figured, 23-in. scale provides easy reading. Scale is stationary; only set point and control point move. Accuracy is promised by manufacturer to be within 0.5%.—**Wheelco Industrial Instruments Div., Barber-Colman Co., Rockford, Ill.** 88C



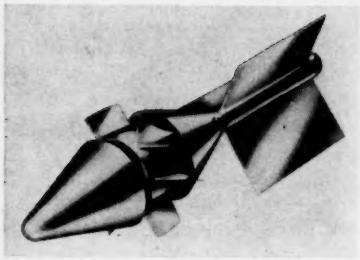
Temperature controller

Miniature automatic device keeps heat level constant within ± 1 F.

Only one fifth as large as former units but able to maintain temperatures within ±1 F., this automatic temperature-controller is intended for panel mounting and visual-signal indication.

Measuring 4¼ × 4 × 5½ in., unit is available in eight temperature ranges between 300 and 2,500 F. Special ranges may be ordered for custom-building.

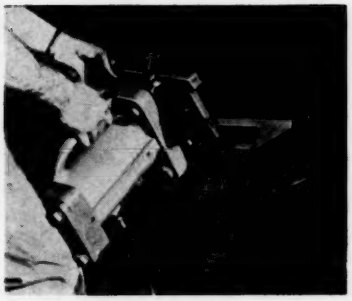
Controller is based on a proportioning action that minimizes overshoot of the set point; an almost flat temperature curve is said to result. Like other automatic meter-relay controllers, the load-relay heart periodically samples heat-source signals—in this case at the rate of six times a minute—although rate of interruption can be field-adjusted by terminal-strip lugs. Failure of line power to the device will automatically shut off heat to prevent uncontrolled damage. — **Assembly Products, Inc., Chesterland, Ohio.** 164A



Transducer

Turbine-type unit is said to be more accurate than any other.

Flow transducer, described as more accurate, more reliable and longer-lived than any turbine-type flowmeter available today, is based on a unique design. Heart of the unit is its rotor, which is maintained in constant hydrodynamic balance without thrust bearings. Free-spinning rotor is said to be first of its kind in turbine-type transducers. — **Francisco Engineering Co., Calabasas, Calif. 165A**

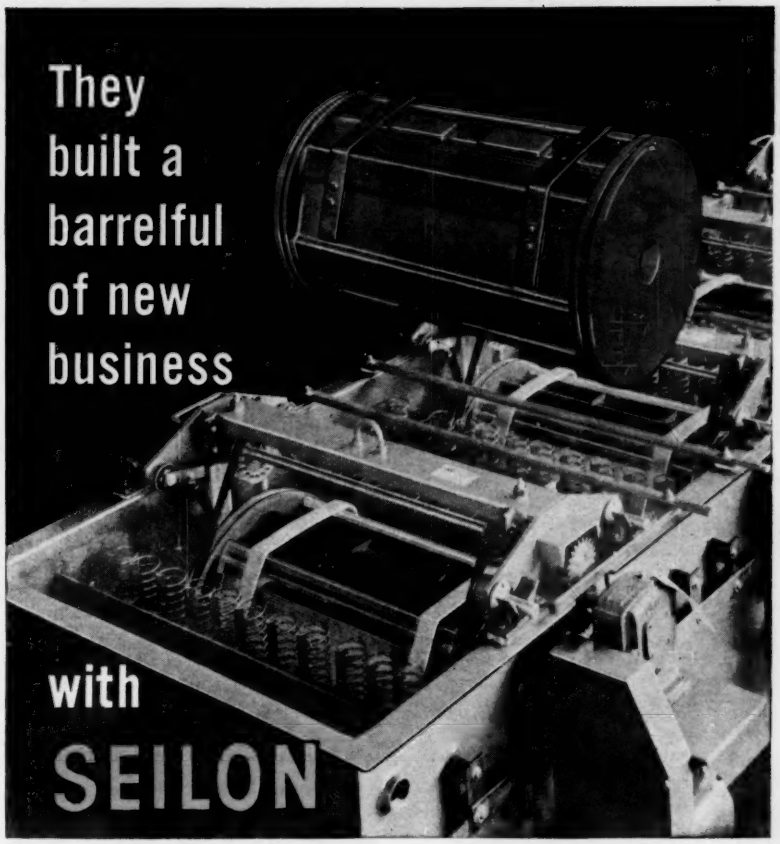


Portable unloading aid

Air vibrator cuts unloading time on railroad hopper cars.

Said to cut unloading time of covered railroad hopper cars by 70%, this heavy-duty air vibrator eliminates the conventional "clean-out" step after emptying cars. Device has also been successfully used on bulk trailers carrying potash, cement and similar materials.

The unit comes in two models: one weighing 68 lb., consuming 18 cfm. at 40-60 psi.; the other weighing 115 lb., handling 29 cfm. at the same pressure.



WHEN YOU DUMP A LOAD OF 2″ BOLTS (or any other heavy parts) into a plating barrel, you had better know what you're doing. Breakage of barrels due to careless loading has long been a problem in the plating industry.

Seiberling technicians recognized this fact, and determined that SEILON PRO, a practically indestructible polypropylene, would be a far superior material to use for the barrels. Seiberling recommended SEILON PRO to the G-S Equipment Company of Cleveland, a manufacturer of replacement plating barrels.

THE RESULT: NEW CUSTOMERS AND A BOOMING BUSINESS! Seiberling provided G-S with technical instruction in handling and hot-welding SEILON PRO. The new barrels, with their remarkable resistance to heat, abrasion, and impact, gained immediate industry acceptance. "In just seven months, our business has grown considerably," says Thomas W. Gulley, Jr., Vice President of G-S. "We attribute this growth, in large part, to Seiberling's superior material and technical competence."

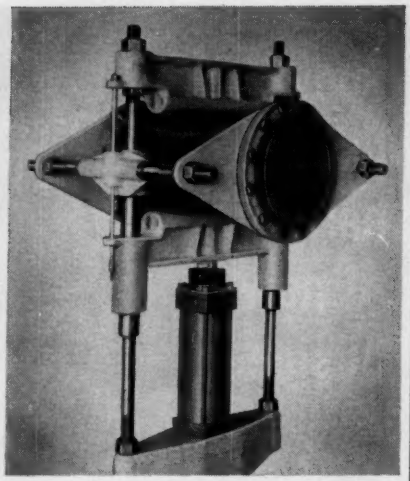
SEILON is versatile in its many properties and tailor-made adaptability to your requirements. We welcome the opportunity to help solve your problems—a letter or phone call will start us working.

SEILON

A NAME YOU CAN TRUST IN PLASTICS

PLASTICS DIVISION
SEIBERLING RUBBER COMPANY
Newcomerstown, Ohio • Phone: HYatt 8-8304

AUTOMATED *Hydral-60* PINCH VALVE SYSTEMS



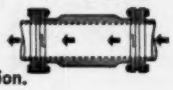
Controlled circuitry for any operating requirements

- The Massco-Grigsby Hydral-60 System consists of one or more pinch valves with a single automatically operated hydraulic pump.
- Hydraulic pump may be operated by electric motor or by air from normal plant supply system.
- Valves may be the same or different size.
- Valves in the system may be operated simultaneously or independently.
- Control valve may be manual or solenoid.
- Valves are self-supporting and may be operated in any position from horizontal to vertical.
- Valves may be coordinated and interlocked with other plant equipment to automatically control tank levels, rate of flow, etc.
- Valves may be independently controlled for normal or rapid closure.
- Valves may be held fully open, fully closed, or at intermediate positions.
- Remote control to meet individual requirements.
- Controls may be included for automatic emergency operation.
- 3" to 14" I.D. sizes, with 50, 100, and 150 psi line pressure ratings.
- Temperatures to 200° F.

Advantages of Massco-Grigsby Pinch Valves

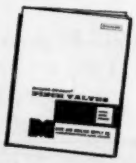
- Rubber, neoprene and special compounded rubber sleeves for corrosive and abrasive pulps and liquids.
- Patented "hinged" sleeve. Recesses serve as "hinges" during compression; reduce strain and permit tight closing.

- Unobstructed flow eliminates high friction loss and prevents contamination.



- Split flanges and patented Flex Seal ends assure perfect seal.
- Rugged, heavy duty construction for most severe service and long life.
- Cannot leak or stick.
- No working parts in contact with pulp or liquid; no packing glands.

WRITE FOR NEW CATALOG NO. 609



The Company that cares enough to give you the best!

MANUFACTURING DIVISION

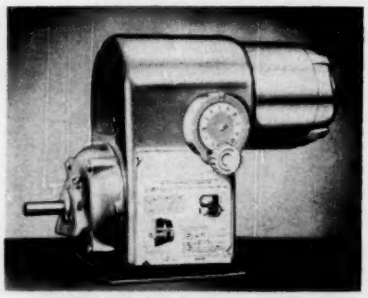
MINE AND SMELTER SUPPLY CO.

Denver 16, 3800 Race St. | New York 17, 122 E. 42nd St. | Salt Lake City 1, 121 W. 2nd S. | El Paso, 1515 11th Ave. | Albuquerque, 701 Haines N.W.

LICENSED MANUFACTURERS AND SALES AGENTS in Canada, Australia, Sweden, England, South Africa
Sales Agents in Mexico, Peru, Chile, Philippine Islands, Japan, New York City (for Continental Europe) and in principal cities of the U. S.

NEW EQUIPMENT . . .

In both models, the piston is the only moving part. Long life is promised by stainless steel head mountings, no body assembly bolts to wear out or fatigue. A hydraulic clamp assembly is also available for attachment to cars not equipped with standard dovetail brackets.—**National Air Vibrator Co., Cleveland.** **165B**



Variable-speed drive

Compact unit gives infinite speed variation from ¼ to 1 hp.

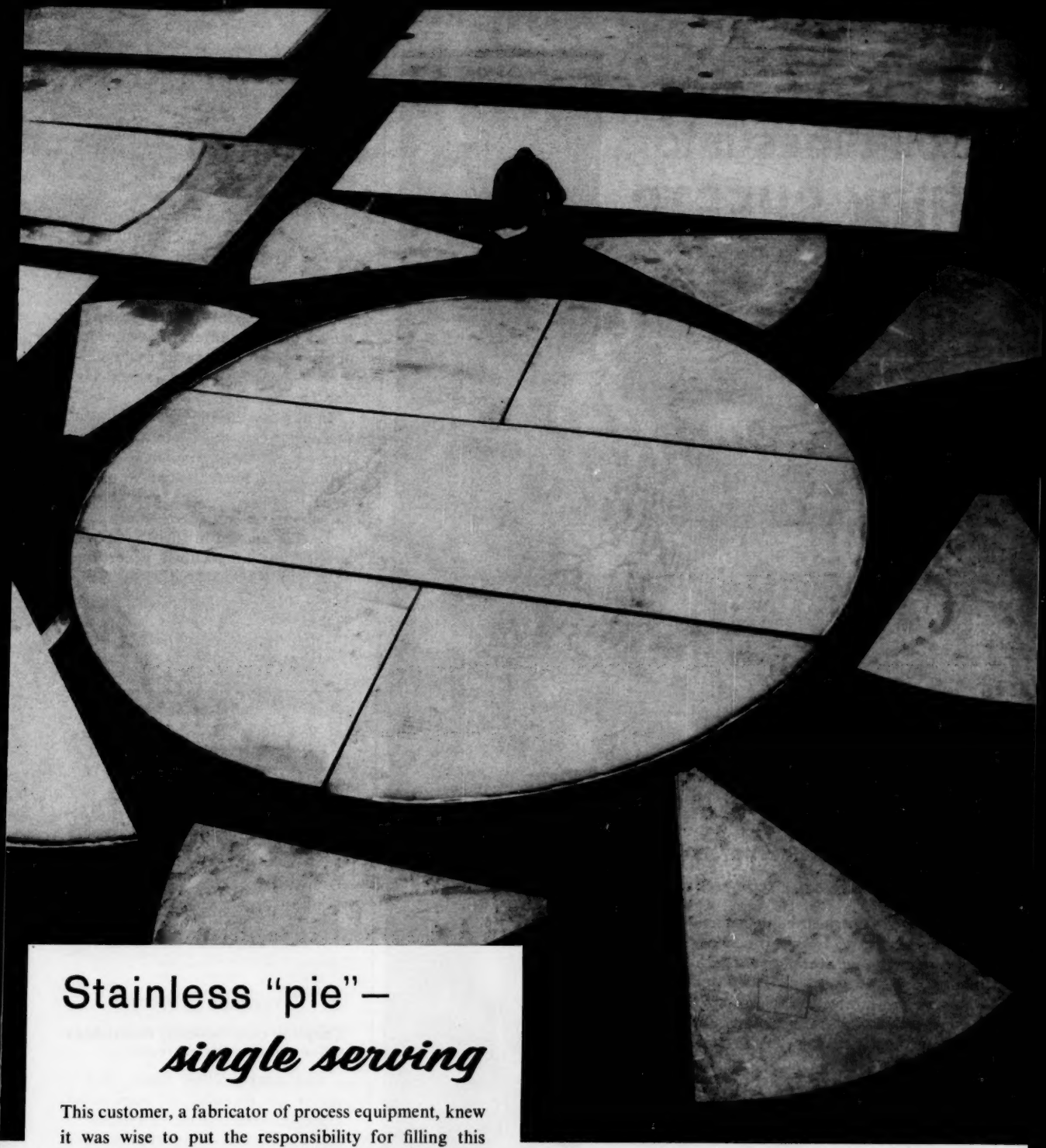
Working over a range of speeds from 4 to 10,000 rpm., a new variable-speed drive is available in ¼-, ⅓-, ½-, ¾- and 1-hp. models. Precise speed settings are ensured with a new control that turns very easily, is prevented from drifting off a given setting by an anticreep device.

Basic features of the device, called Varidrive, are: automatic tension adjustment of the belt, slots in the base to permit variety in mounting, a lubrication system that flushes out old grease and replaces it with new. In ½-hp. size, the unit weighs 63 lb., is 14½ in. high, 8½ in. wide.—**U. S. Electrical Motors, Inc., Los Angeles.** **166A**

Zone refiner

Electron beam device purifies metals, grows single crystals.

Using electron beam bombardment to attain temperatures up to 6,000 F., a new zone refiner can be used to purify and grow single



Stainless "pie"—
single serving

This customer, a fabricator of process equipment, knew it was wise to put the responsibility for filling this stainless steel order in the hands of a single producer—G. O. Carlson, Inc. He knew that our specialists, working with modern equipment, would make each item of the order "to specification." And he also knew that our delivery promise is a trust that we fulfill.

For your order—or orders—of stainless steel plate and plate products, come to Carlson. Here skilled men, working with the finest equipment, are determined to match your every wish.

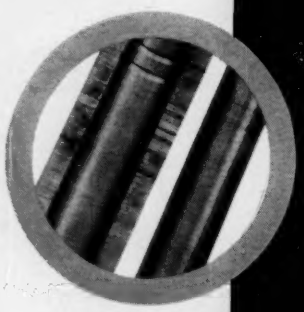
G.O.CARLSON *Inc.*

Producers of Stainless Steel

134 Marshallton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • BARS AND SHEETS (No. 1 Finish)

Roll tubes into THICK SHEETS in one pass



Use of **NEW** continuous-rolling technique here—shows uniform seal, with all Keys preserved, and no signs of shear

OLD step-rolling method results in non-uniform surface . . . distortion of Keys where rolls have overlapped

Better seal . . . Smoother surface . . . Much Faster operation

This new concept in tube expanders was developed by Elliott to roll the thickest tube sheets. Using a continuous-rolling method, it eliminates many problems common to step-rolling, may be operated protractively or retractively, saves time, assures uniform, smooth surfaces, avoids annular voids or erratic tube inside diameters, provides better seal.

Accessories

Elliott also makes a complete line of retubing accessories, including both electric and air magnetic Tube Rolling Controls, Tube Gages, Tube Plugs, Tube Cutters, etc.—in addition to a complete line of tube expanders. *Ask for Bulletin Y-52.*

Y1-4

ELLIOTT COMPANY

GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio; Newark, N. J.

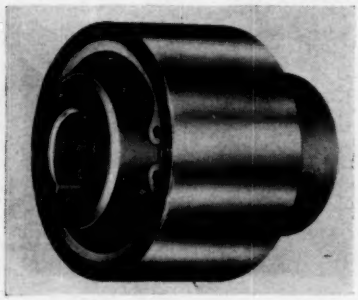
TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS
DEAERATING HEATERS • EJECTORS • CONDENSERS • STRAINERS • TUBE CLEANERS

crystals of refractory metals, metal compounds and ceramics, and to deposit these metals in the vapor phase.

In operation, electrons from a tungsten emitter are concentrated in an extremely narrow zone by a specially designed scanner. When the zone in the specimen reaches the molten state, the scanner moves on to an adjacent area, thus continues up and down the specimen as many times as necessary for purification.

Impurities in the specimen rod are either vaporized into the chamber where high vacuum is maintained, or concentrated at both ends of the specimen and subsequently cut off.

Unit is housed in three sections, with controls grouped according to function and placed within easy reach of the operator, who can keep tabs on the process through a safety window.—**MRC Mfg. Corp., Yonkers, N. Y.** **166B**



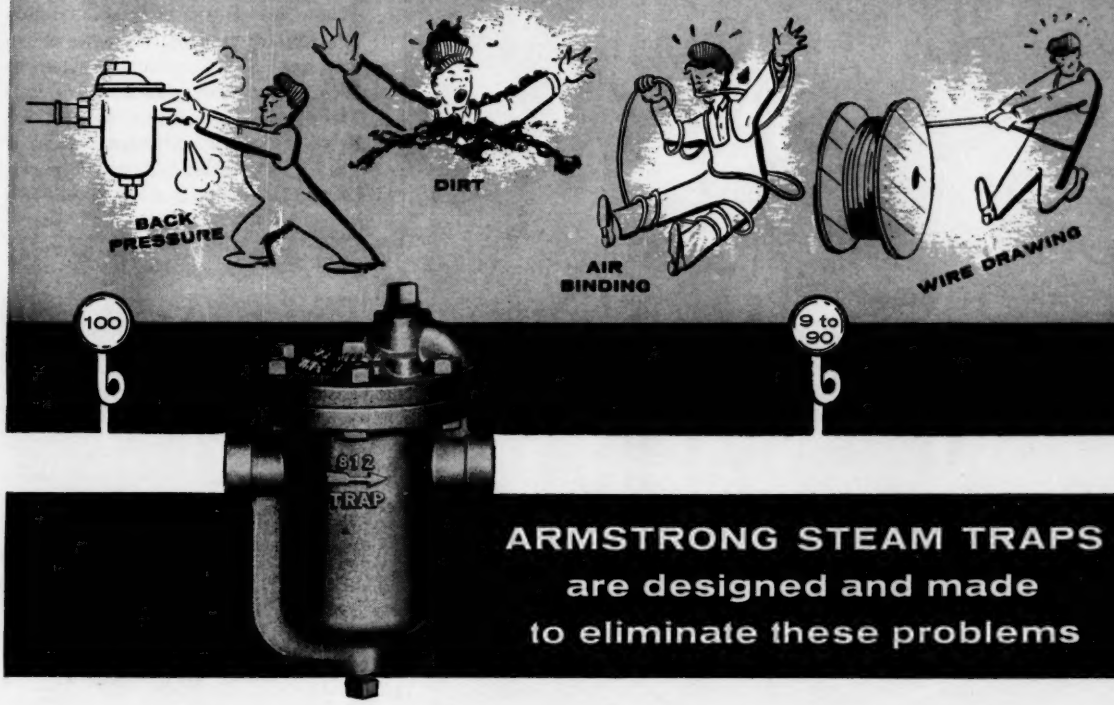
Overload protector

Coupling automatically re-engages when overload is corrected.

The next million times that a motor or machine is overloaded shouldn't cause a bit of trouble if the shafts are connected with a new overload protector called the Torq-Tender. Warranted for a million disconnect-reconnect cycles (or six months), the device fits shafts from $\frac{3}{8}$ to $1\frac{1}{2}$-in., can be preset to disengage at any torque setting from $\frac{1}{2}$ to 60 ft.-lb.

Automatically re-engaging when overload is corrected, unit can remain for an unlimited time in the

Have you ever been troubled by any of these steam trap problems?



ARMSTRONG STEAM TRAPS are designed and made to eliminate these problems

BACK PRESSURE . . . Armstrong Traps operate on any back pressure—or vacuum, for that matter. As long as there is a pressure differential across the trap, it will close on steam and open for condensate. Even the high back pressure caused by blow through of one or more traps in the system will not disturb Armstrong Traps. Other than a reduction in capacity, Armstrong Traps are unaffected by back pressure.

DIRT . . . Armstrong Traps are not affected by ordinary dirt. When the trap opens condensate swirls down under the edge of the bucket and up through the discharge orifice. Dirt is kept in suspension and discharged along with the condensate. For very bad dirt conditions, Armstrong offers traps with integral strainers. These cost less than a trap plus a separate strainer.

AIR BINDING . . . Armstrong Traps cannot air bind. Air in the system passes through a vent in the top of the bucket. It collects in the top of the trap and is discharged with the condensate. There is no chance for it to stop the trap. For low pressure on-and-off units where large amounts of air accumulate while the steam is off, Armstrong offers open float and thermostatic air vent traps in a complete range of sizes.

WIRE DRAWING . . . Armstrong Traps are designed and made to resist wire drawing. The valve and seat are tough stainless steel. The valve opens and closes tightly with a fast action and is always water sealed. There is virtually no chance for grit or sediment to lodge in the valve, virtually no chance to create conditions that lead to wire drawing.

There's no need to accept any of these problems as "inevitable." Your local Armstrong Representative can show you how to end them all. Call him today or write direct.

860 Series for low pressure heating service.

800 Series, side inlet, side outlet.

No. 801, side inlet, bottom outlet.

880 Series, integral strainer.

200 Series, bottom inlet, top outlet.

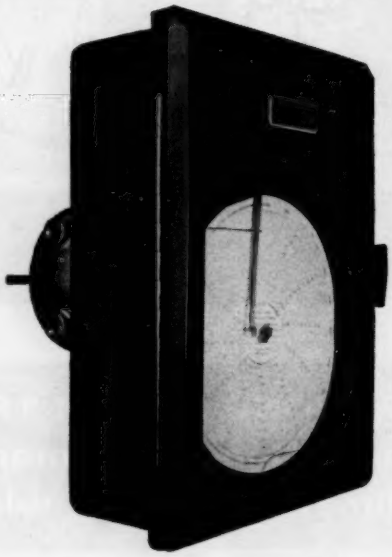
Forged Steel Series for high pressures, high temperatures.

The 48 page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

ARMSTRONG MACHINE WORKS

8582 MAPLE STREET THREE RIVERS, MICHIGAN

THE FLOW RECORDER YOU CAN COUNT ON



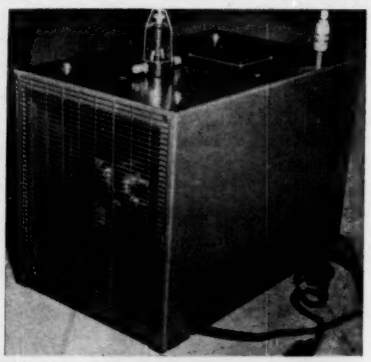
Absolute dependability, under the most demanding operating environments—that's the promise and the performance of the Barton 202A flow recorder. Thoroughly proven in the gas production fields, the 202A is enjoying ever-increasing popularity in gas transmission and distribution systems. It is compact and ruggedly built, not subject to the usual frailties of such a precise instrument; it has built-in overrange protection, which allows it to maintain calibration under wide pressure fluctuations; it is immune to condensate problems, making it ideal for application in all geographical areas. A recently added bonus: the 202A can be fitted with the new Barton chart changer which allows the instrument to record continuously and unattended, for up to 16 days, using a fresh chart each day. For complete information and specifications on the 202A flow recorder, request Bulletin 202A-1.

BARTON

RECORDER-INTEGRATORS/CONTROLLERS/DIFFERENTIAL PRESSURE INDICATORS/PNEUMATIC TRANSMITTERS/FLOW SWITCHES

BARTON INSTRUMENT CORPORATION • MONTEREY PARK, CALIFORNIA

disengaged position without overheating or binding. It always reengages in the same position, so there are no timing problems. Torq-Tender can be used in direct drive or with sprocket, gear or pulley. — **Helland Inc., Navarre, Minn.** 168A



Heat exchanger

Design for continuous use, new unit is rated at 12,000 Btu./hr.

For continuous operation with ambient air at 100 F. and inlet water at 180 F., this heat exchanger is a self-contained package measuring 24 × 15½ × 20 in. It consists of positive-displacement pump, 1.5-gal. reservoir, heat-removing radiator unit, fan, flow indicator, and associated fluid fittings. The pump delivers 1.25 gal./min. at a discharge pressure adjustable to 100 psi.—**The Strong Electric Corp., Toledo, Ohio.** 170A

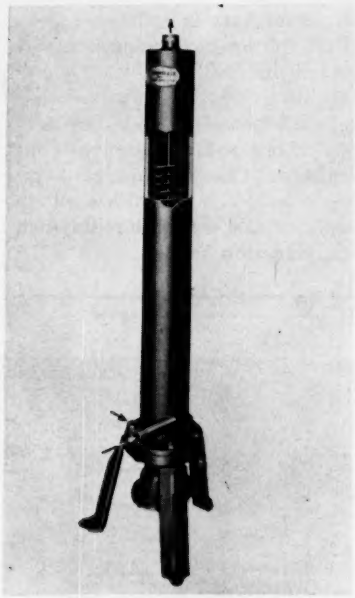
Gas detector

Multipoint monitor sounds the alarm on highly flammable gases.

Presence and concentration of combustible gases at varying locations are monitored by sensing elements connected to a central unit by cables that can be up to 1,500 ft. long. Danger level of concentration is read in terms of percent of lower explosion limit of the hazardous gas; when gas con-

centration exceeds safe point, both alarm and shutdown circuits are triggered. System is electrical throughout, with neither tubes nor transistors.

Up to five separate channels (i.e. detecting - indicating - alarm circuits) may be connected to the central panel, all on 24-hr. duty. To date, the gas-detecting device has been installed in two major missile-testing facilities (Florida, Alabama) for hydrogen detection; it is also in operation in refineries and explosives plants. — **Houston Instrument Corp., Houston. 170B**

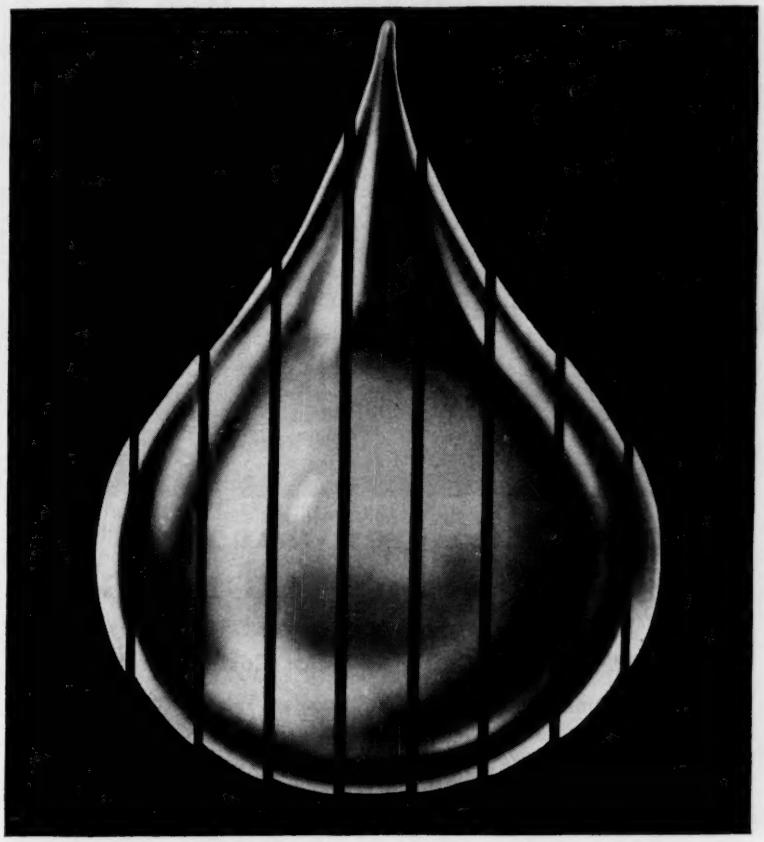


Aftercooler

Air-to-water heat exchanger is designed for small capacities.

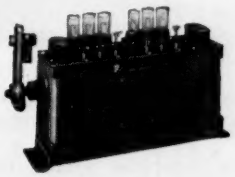
To cool 50-120 cfm. of free air, this compact aftercooler comes in over-all lengths from 40⅜ in. to 95¼ in., with a cooling chamber of only 4½-in. dia. Unit features noncorrosive copper water-cooling coil and a float trap that ejects separated moisture without loss of air. The cooler also offers optional automatic cooling-water shutoff and horizontal design for fit to overhead piping.—**Jas. A. Murphy & Co., Inc., Hamilton, Ohio. 171A**

HOW THIN can you



slice a drop of oil?

Whether you want to deliver several drops or the minutest fraction of a drop per piston stroke, a Manzel lubricator will do the job exactly. Manzel lubricators force oil of any viscosity against the high steam, gas and air pressure so common in modern compressors, engines and machines. They start, stop, speed up or slow down in synchronization with your equipment. Write for our catalog explaining the whole line. Manzel, 250 Babcock Street, Buffalo 10, New York. For efficient lubrication



ask the man from

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

...When Management Puts The Spotlight on WEIGHING

PRINTWEIGH® RECORDS: a Major Cost Control Tool

Materials become money . . . on your scales. Weight records directly affect costs, quality control, inventories and customer billing. That's why it pays to put the spotlight on weighing . . . and make sure you have the right TOLEDO scale at every weighing point.

A close look at weighing is especially called for if you've made changes in plant layout, materials handling methods, or inventory controls. In any of these areas, scales that don't fit the job can bottleneck operations, infect weight records with costly errors.

Complete Printed Weight Records with TOLEDO PRINTWEIGH "400"

Prints complete weight records on tickets, sheets or strips. Transmits weight data to remote locations where it is recorded by office machines, if desired. Ask for Bulletin 2017.

We'll be glad to help you evaluate weighing efficiency in your operations. A few minutes at each weighing station will put the spotlight on scale capacity and location, dial visibility, platform size and height and other important factors. Send for Bulletin 2036. TOLEDO SCALE, Division of Toledo Scale Corporation, Toledo 12, Ohio.

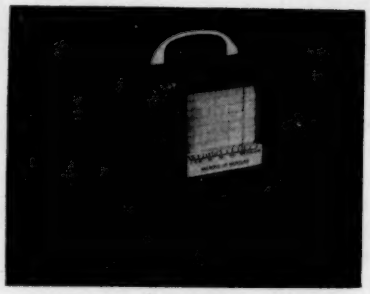
(Toledo Scale Co. of Canada Ltd., Windsor, Ont.)

SERVICE

TOLEDO®

Headquarters for Weighing Systems

NEW EQUIPMENT . . .

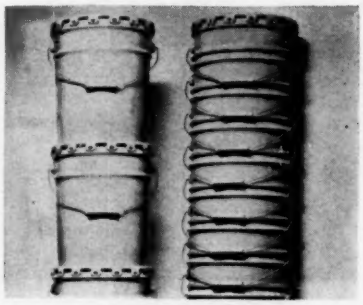


Vacuum recorder

Miniature unit measures pressure on 1,000-micron or 20-mm. scales.

Suitable for bench or panel-mounted installations, this vacuum recorder is only 3⅝ in. wide, 5⅝ in. high. Range of readings are 0-1,000 micron in one model, 0-20 mm. of mercury in another.

Full voltage regulation is incorporated in each circuitry, along with interchangeable tubes that are said to withstand "tremendous" shock and vibration without breakage. Chart paper and recorder scales are calibrated in absolute units.—**Hastings-Raydist, Inc., Hampton, Va.** 172A

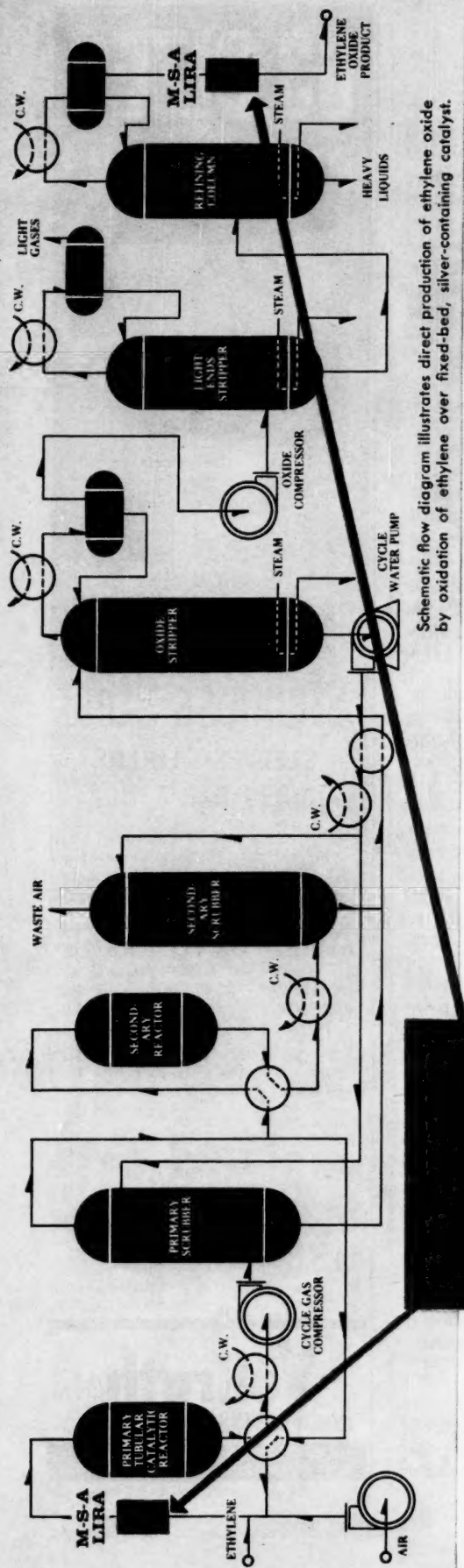


Steel pail

Tapered pails nest for shipping, storage; take up less space.

Sixteen of these new 5-gal. tapered nesting pails can be stored in the space required by five empty straight-sided ones. When filled and stacked, bottom of pail locks into depressed panel in cover of pail below, so a stack of full ones can be tipped and rolled as one unit.

Tapered pail side has a bead



Schematic flow diagram illustrates direct production of ethylene oxide by oxidation of ethylene over fixed-bed, silver-containing catalyst.

ANOTHER PROBLEM-SOLVING APPLICATION OF M-S-A® LIRA ANALYZERS:

helping to keep reactors operating at peak efficiency in ethylene oxide plants

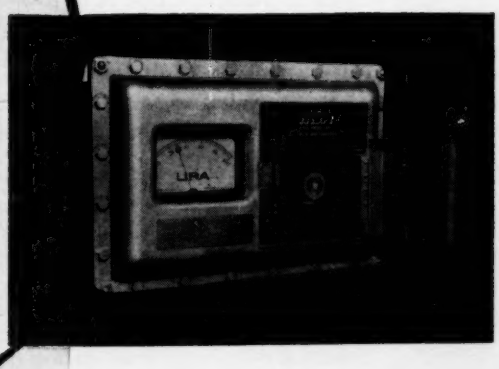
Catalytically oxidizing ethylene to ethylene oxide? You can do it safer, at a greater rate, at less cost by measuring both ethylene input and ethylene oxide product with M-S-A LIRA Model 200 Infra-Red Analyzers

M-S-A LIRA Analyzers can save more than they cost in a matter of months. And they can contribute mightily toward bringing the plant to peak efficiency.

A striking example of this interesting claim is the use of Model 200 LIRA Analyzers in processing ethylene oxide by direct oxidation of ethylene. In this process, LIRAs are used to measure the ethylene in relation to the oxygen input into the reactor. This in turn assures peak operating efficiency of the reactor.

The Model 200 is also used in this process to measure the purity of ethylene oxide being produced as the final product. No need for manual tests for product quality. It's automatic. Continuous. And that's where some of the biggest savings lie. Let's face it: manpower used in process monitoring is expensive. So, let the LIRA do it.

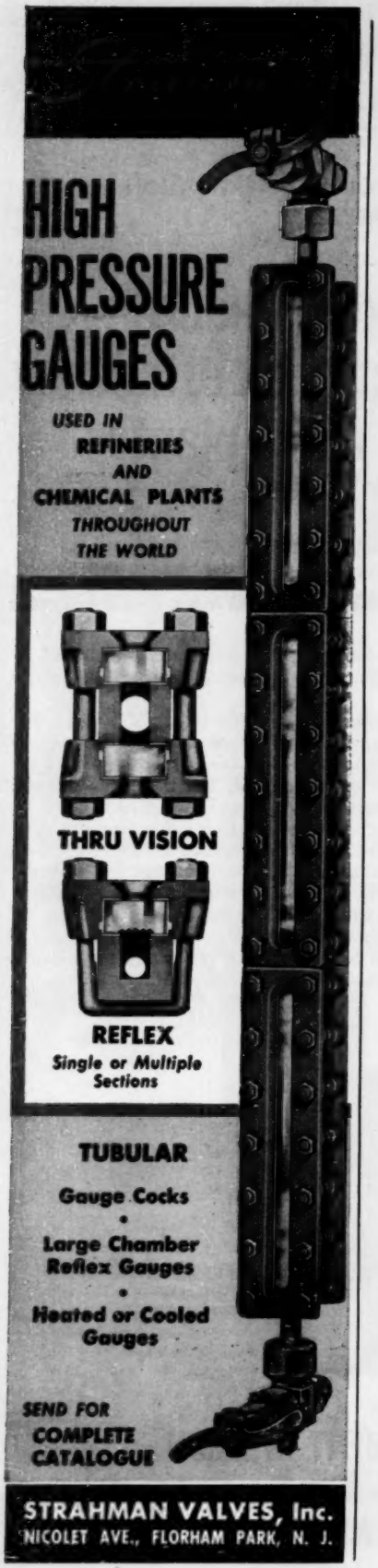
An M-S-A Instrument Specialist will be happy to put our ingenuity to work on your process stream problems: safety, product quality, measurement or control. Consult him. Or write us for helpful literature.



Explosion-proof Model 200 has a tamper-proof lock. All self-checking circuit controls are easily accessible through the explosion-proof enclosure.

INSTRUMENT DIVISION

Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania



that allows nesting without having pails stick together, since point of contact is at the bead and not in the taper. Bead overlaps the opening, keeps pail interiors clean during shipping or storage. Cover is same size as standard straight-sided pail lid, is dogged with the same closing tool.—**Bennett Industries, Inc., Peotone, Ill.** 172B

Briefs

Rotary knife cutter handles film sheets up to 48 in. wide. Designed primarily for the granulating of roll-fed scrap, or sheets as thin as 0.001 in., machine is said to hold clearances to within 0.003 in. —**Sprout, Waldron & Co., Inc., Muncy, Pa.** 174A

High-speed gas chromatograph for multicomponent process streams can monitor and control such operations as distillation tower fractionation, alkylation reactions and maintaining of gas ratios in sulfur recovery plants. Unit works with either electrical or pneumatic control systems, operates via a programmer that's part of a peak-reading controller.—**Perkin-Elmer Corp., Norwalk, Conn.** 174B

Size gage for O-rings enables users to check the I.D. and cross-section of the rings with a minimum of effort. Unit consists of a cone that measures diameters, and a slotted base for measuring cross-sections. — **Parker Seal Co., Culver City, Calif.** 174C

Compressed asbestos sheet packing has tensile strength of 8,000 psi., withstands flange temperatures up to 1,100 F. where internal temperature may go as high as 1,400 F. Only long spinning-grade asbestos fibers are used to make the product. — **Raybestos-Manhattan, Inc., Passaic, N. J.** 174D

Flexible shaft of stainless steel is for high-temperature or corrosive operations. Squared ends provide engagement, and allow for slight

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changes in length due to varying torques. Shaft comes in any required length.—**Stow Mfg. Co., Binghamton, N. Y.** **174E**

Explosionproof plugs and receptacles for safe use of permanent or portable electric lighting and power distribution systems consist of electrical-grade copper, solidly encased in a neoprene body. When plug is inserted into receptacle, a lip and collar must be engaged, forming a sealed chamber. Only after chamber is closed can plug be turned to bring contacts together to complete circuit.—**J. B. Nottingham & Co., Inc., New York.** **175A**

Drum and pail pump is self-priming, self-venting, comes in two sizes to fit different containers. Small model for 5- and 6-gal. pails fits all sizes and types of pail openings, dispenses exactly 4 oz. per stroke. Larger model for 15, 30 and 55-gal. drums dispenses 8 oz. per stroke.—**Multi-Meter Corp., Toledo, Ohio.** **175B**

Equipment Cost Indexes . . .

	Sept. 1960	Dec. 1960
Industry		
Avg. of all	237.4	237.3
Process Industries		
Cement mfg.	231.7	231.6
Chemical	238.6	238.2
Clay Products	225.6	225.1
Glass mfg.	225.3	224.8
Paint mfg.	229.1	229.4
Paper mfg.	229.9	229.4
Petroleum ind.	234.0	234.3
Rubber ind.	237.9	237.1
Process ind. avg	236.2	236.7
Related Industries		
Elec. Power equip	240.2	238.3
Mining, milling	240.0	239.5
Refrigerating	267.7	268.0
Steam power	224.3	224.5

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; this issue, pp. 115-116 for annual averages since 1913.

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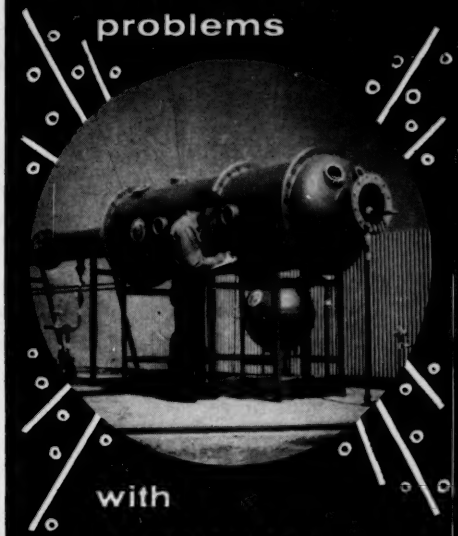

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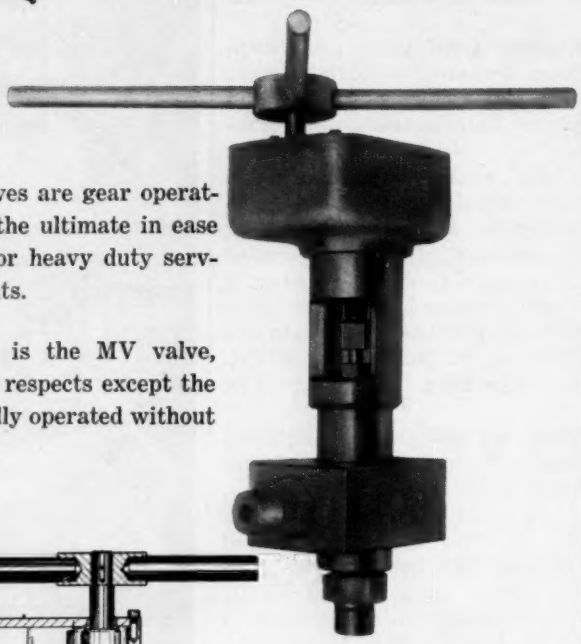

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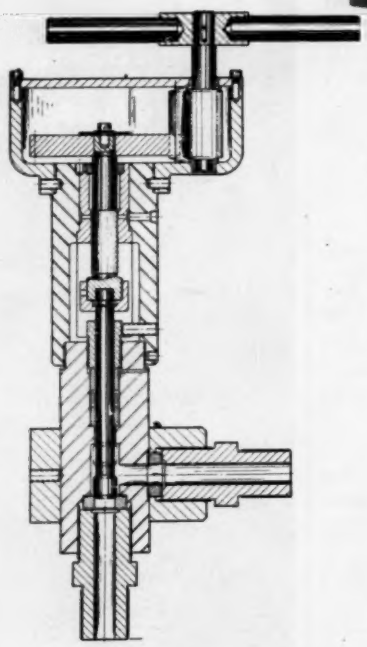

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Technical Bookshelf

SPOTLIGHT ON SPECTRA

THE ENCYCLOPEDIA OF SPECTROSCOPY. ED. BY GEORGE L. CLARK. REINHOLD PUBLISHING CORP., NEW YORK. 787 PAGES. $25.

Reviewed by Sidney Siggia, Olin Mathieson Chemical Corp., New Haven, Conn.

An encyclopedia in the standard definition, this is a compilation of concise articles describing the various aspects of spectroscopy. The book is divided into 23 main headings, covering the various areas of the subject including absorption, emission, band, mass, magnetic resonance, beta-ray, gamma-ray, microwave, X ray, and fluorophotometry and phosphorimetry. Each area is then subdivided into individual articles that describe the various aspects of which the main field is composed, as in any encyclopedia. Articles are rather short, are meant mainly to give the reader an over-all view. In general, minute detail is not included.

There are 160 contributors, each particularly well known in the aspect of spectroscopy being described. This reviewer would question only one item: the inclusion of Differential Thermal Analysis in a volume such as this. But this is a very minor point and does not detract at all.

The text makes a wonderful reference, compactness of articles enabling the reader to rapidly determine what is being described, and its standards in terms of technology are very high. There is ample use of illustrations and tables, and a bibliography is included at the end of each article. I feel the encyclopedia fills a gap in the technical literature.

And Also Received

Engineering and Technical Conventions (1961) is an annual listing, prepared by Deutsch & Shea, Inc., which gives advance information on meetings. Current edition carries meeting dates through '65; tells where, when, how long and,

sometimes, number of attendees expected. A geographic index is included, as is a list of organizations and their mailing addresses. Write: Industrial Relations News, Inc., 230 W. 41st St., N. Y. 36, N. Y. Single copy: $4 (also includes a supplement published in the fall).

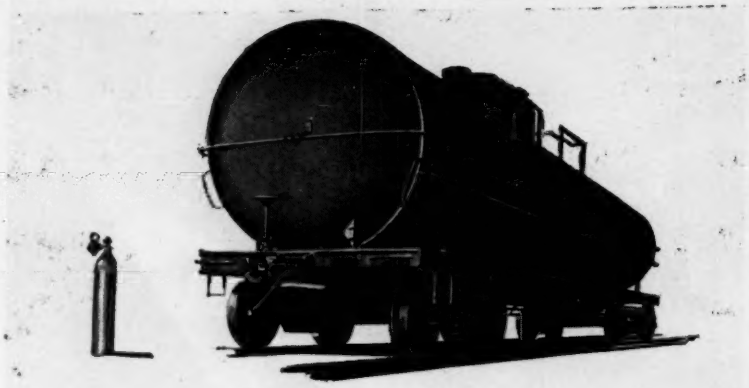
Plastics as Building Construction Materials. Structural Plastics Associates, P. O. Box 13, Belmont, Mass. 129 pages. $18.50. Another student report comes out of Professor Doriot's course at the Harvard Graduate School of Business Administration. The seven authors have picked a juicy, controversial topic, written a too bland commentary. A lot of ground is covered, however; there are chapters on (1) applicability of plastics to building construction, (2) building codes, (3) trends affecting the acceptance of plastics as building materials, (4) influence groups, (5) cost analysis.

The Science Doctorates of 1958 *and* 1959. The National Science Foundation has issued a comprehensive set of statistics on science Ph.D.'s. Survey includes discussion of age of new doctorates, time lapse between Bachelor's and Ph.D., postdoctorate plans, geographic factors in employment. Write: Supt. of Documents, U. S. Govt. Printing Office, Washington 25, D. C. Price: 25¢.

In Rapid Review

Official Methods of Analysis of the Assn. of Official Agricultural Chemists. Ed. by W. Horowitz, Assn. of Official Agricultural Chemists, P. O. Box 540, Benjamin Franklin Station, Washington 4, D. C. 832 pages. $17.50 (foreign postage, add 50¢). This is the ninth edition of the standard work on analysis of foods, other agricultural products and agricultural chemicals. While drugs, coloring matter and preservatives are also covered, major emphasis is on foods. Recent federal legislation closely regulating food additives makes this volume particularly pertinent at present.

Space Biology—the human factors in space flight. By J. S. Hanrahan and D. Bushnell. Basic Books, Inc., New York. 263 pages. $6. This book describes man's needs and capabilities in outer space. It covers problems of food,



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air and water intake, and waste disposal; acceleration and weightlessness; radiation and re-entry hazards. Surveying an enormous mass of data, it contains 40 pages of notes and references.

More New Books

The Fermi Surface. Ed. by W. A. Harrison and M. B. Webb. Wiley. $10.

Modern Chemical Processes. Vol. 6. By the editors of *Industrial & Engineering Chemistry.* Reinhold. $6.

Analogue Computation. 4 vols. By S. Fifer. McGraw-Hill. $39.50.

Preparative Methods of Polymer Chemistry. By W. Sorenson and T. W. Campbell. Interscience. $10.50.

Aerosols—science and technology. Ed. by R. A. Shepherd, et al. Interscience. $22.50.

Frontiers of the Sea—the story of oceanographic exploration. By R. C. Cowen. Doubleday. $4.95.

Management of Nuclear Materials. Ed. by R. F. Lumb. Van Nostrand. $16.50.

Controlled Thermonuclear Reactions. By S. Glasstone and R. H. Lovberg. Van Nostrand. $5.60.

Handbook of Textile Testing and Quality Control. By E. B. Grover and D. S. Hamby. Textile Book Publishers, Inc. (div. of Interscience). $17.50.

Determination of the Mechanical and Technological Properties of Metals. By B. M. Gliner. Pergamon. $8.50.

Modern Insecticides and World Food Production. By F. A. Gunther and L. R. Jeppson. Wiley. $8.50.

Manual for Plastic Welding—Vol. 3: polyvinyl chloride. By G. Haim. Chemical Publishing Co., New York. $15.

An Introduction to Transition-Metal Chemistry: Ligand-Field Theory. By L. E. Orgel. Wiley. $4.50.

Organic Coating Technology. Vol. 2: Pigments and Pigmented Coatings. By H. F. Payne. Wiley. $17.50.

Centrifugal Pumps: selection, operation and maintenance. By I. Karassik and R. Carter. F. W. Dodge Corp., 119 W. 40 St., New York 18, N. Y. $15.75.

Servomechanisms. By P. L. Taylor. Longmans, Green Co. $8.50.

Engineers and What They Do. By H. Coy. Franklin Watts, Inc. $3.95.

Letters: Pro & Con

Flanked by newcomers Popper and Hughson: Senior Associate Editor Bob Norden.

Dear Readers:

This trio of *Chemical Engineering* editors—one veteran and two newcomers—figure in a rearrangement of staff responsibilities aimed at further strengthening and improving our editorial content.

After seven years of editorial experience, following six years in industry, Robert B. Norden will assume broader responsibilities in the planning, development and handling of feature articles and reports. Bob is unusually adept at spotting flaws in manuscripts and article ideas that might otherwise go undetected. On the other hand, he can often find something worthwhile in many manuscripts that other editors might reject. Along with Bob's enlarged responsibilities goes a new title—that of Senior Associate Editor.

The two latest additions to our staff, also shown above, are Roy V. Hughson and Herbert Popper. Roy will inherit Bob's mantle as Corrosion Forum editor; Herb will be handling our Operation & Maintenance department. While new to the editorial profession, both Roy and Herb bring to their new jobs rich backgrounds of engineering experience.

Roy Hughson is a chemical engineering graduate of New York University, class of 1947. Interested in a career in teaching, he earned a master's degree in Science Education from NYU in 1951, but then decided against teaching in favor of engineering practice. This led to an eight-year period of employment with Standard Brands at its Fleischmann Laboratories in Stamford, Conn. Roy left his job there as head of the Coffee Technology Division to join *CE* in December. His extracurricular interest in the realm of language, even as an engineer, was evidenced by membership in the International Society for General Semantics.

When Herbert Popper came with us last month, he returned to his first love—journalism. Herb began his college career as a journalism student but let himself be talked

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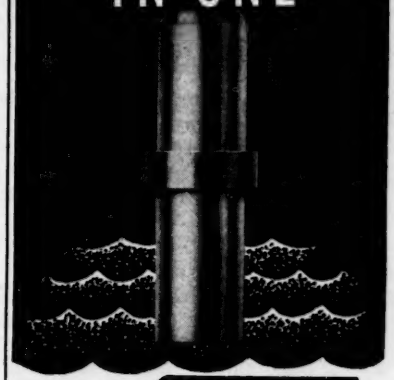

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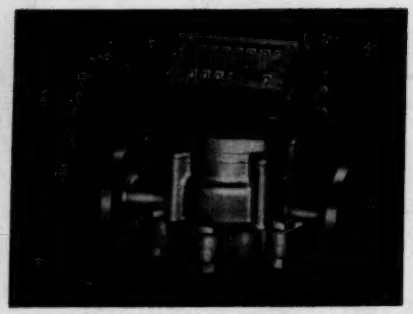

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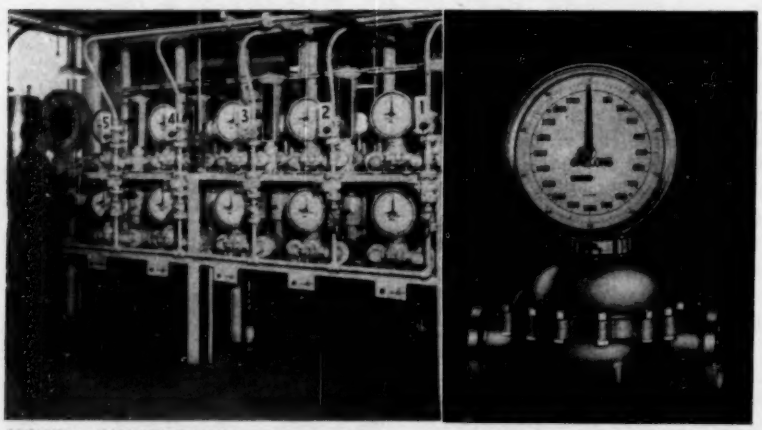

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into the industrial management curriculum as a better way to a livelihood. Thus he graduated from College of the City of New York in 1949 with a degree in the latter field. Realizing the value of additional technical knowledge, Herb followed up with another degree, this one from NYU in 1955, in chemistry and mathematics, then continued his technical education still further with evening courses in chemical and electrical engineering subjects. He comes to *CE* from five years at Procter & Gamble's Clorox plant in Jersey City, his most recent title Plant Engineer.

One odd twist in the above assignments: While at Standard Brands, Roy Hughson once had a young engineer working for him named Peter Brennan. Later on, Pete joined the staff of *CE*. His enthusiasm for our kind of editorial work rubbed off on his former boss, inspiring Roy to contact us about the job he now fills. But the renewed association of Standard Brands alumni was short-lived; Pete recently accepted a once-in-a-lifetime kind of job offer in southern California and fled just in time to escape our Feb. 4 blizzard.

CECIL H. CHILTON
Editor-in-Chief
Chemical Engineering

Old Products, New Maker

Sir:

In your Nov. 28, 1960, issue (p. 98), you introduced two products which were developed by W. R. Grace & Co.—a textile softener referred to as Aquazine-100 and an antistatic agent billed as Aquazine-88.

Your news item inadvertently failed to mention that license was acquired from Grace by Moretex Chemical Products, Inc., Spartanburg, S. C., to produce these quaternized hydrazinium compounds for the indicated applications. Moretex now tailor-makes these compounds for use in textile wet processing, and markets them under their patented trade names, the Aquazines.

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2	30	47	80A	85	127b	152c	160	170	L175	185B	190A	194D	T199	L211
4	31	48	81	86A	127c	152d	161	170A	R175	185C	190B	194E	B199	R211
6-7	32	50	82A	86B	129	152e	162	170B	175A	185D	190C	194F	199A	L212
8-9	33	57	82B	87A	133	152f	163	171	175B	186	192	TL195	L200	R212
10-11	34	61	82C	87B	135	152g	164	171A	176	186A	192A	BL195	R200	TL213
12-13	35	63	82D	87C	137	152h	164A	172	177	186B	193	R195	T201	BL213
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16-17c	39	67	84C	88C	145	152l	166	L174	184	188	193D	196C	202B	TR214
20-21	40	69	84D	89	147	153	166A	R174	184A	188A	193E	TL197	202C	BR214
22	42	71	84E	95	149	155	166B	174A	184B	188B	194	BL197	202D	215
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- **ADS**
- **PRODUCTS** page 80
- **EQUIPMENT** page 86
- **SERVICES**
- **LITERATURE** page 184

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Manufacturers' Literature

Contents of This Issue

Chemicals

Aluminum.....Plant upkeep is cut substantially with structurals and equipment made of aluminum. It resists corrosion and weathering. Literature available.
187 *Reynolds Metals Co.

Chemicals Catalog.....Contains item and size listing of companies complete line. Packaging ranges from individual pound packages to bulk track or industrial tanker loads.
184A F. P. Jay Chemical Corp.

Chloride Determination.....2-page data sheet describes continuous automatic method for determining chloride content of water in concentrations down to 10 parts per billion.
184B Technicon Controls, Inc.

Chlorine.....The Chlorine Manual is now available on request. Its 76 pages are full of useful chemical and engineering information.
127c *Hooker Chemical Corp.

Citric Acid.....A methodology for the rapid, automatic determination of citric acid is described in a 2-page data sheet. Flow diagram shows how system operates.
184C Technicon Controls, Inc.

Colloidal Silicas.....Properties and characteristics of Nalcoag colloidal silicas are described in Bulletin K5, which is now available on request.
151 *Nalco Chem. Co.

Driers and Drying Oils.....Brochure discusses properties and composition of driers and drying oils used in paints and printing inks, formulation recommendations and calculations.
184D Witco Chemical Co. Inc.

Filter Fabrics.....offer maximum chemical and heat resistance, high abrasion resistance, and efficient cake retention-and-discharge properties.
158 *United States Rubber

Formaldehyde.....Various types to meet your needs such as stabilized formaldehyde, paraformaldehyde, formcel solutions in alcohols and trioxane anhydrous.
73 *Celanese Chemical Co.

Lithium Compounds.....Folder lists and describes lithium compounds available either commercially or on experimental basis; includes present and suggested uses.
185A Foote Mineral Co.

Oxalic Acid.....Sulfates are kept to a typical low 150 to 300 ppm. Made in two crystal sizes and as non-dusting as possible. For further information Data Sheet 789.
127a *Hooker Chemical Corp.

Phosphoric Anhydride.....is used in new process to recover uranium oxide from crude ores. Substitutes solvent extraction for phosphate precipitation method. Data Sheet.
127b *Hooker Chemical Corp.

Polyester Resin.....Technical bulletin describes properties of resin used in production of solid-cast urethane elastomers that exhibit low-durometer hardness characteristics.
185B Witco Chemical Co.

Polypropylene.....Seilon Pro is a practically indestructible polypropylene. It is versatile in its many properties and tailor-made adaptability to your requirements.
165 *Seiberling Rubber Co.

Silicone Rubber Chart.....Chart designed to assist designers and engineers in selection of proper type of silicone rubber includes data on properties and primary classes.
185C General Electric Co.

Solvent.....Samples and information on Pent-Oxone solvent including complete graphs on viscosity and evaporation and its keto-ether action are available on request.
50 *Shell Chemical Co.

Vinyl Resins.....Vinyl plastisol and organosol technology is discussed in detail in 24-page brochure that covers all aspects of formulation, processing methods and applications.
185D Union Carbide Plastics Co.

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All cycle components are pneumatically operated, too, and this feature eliminates the possibility of introducing impurities into the product through lubrication or hydraulic leakage.

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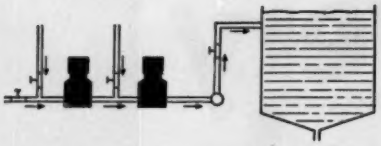
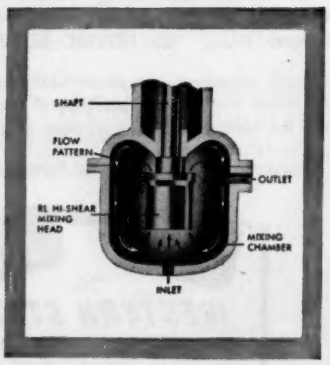
2775

NEW SHEAR-FLOW CONTINUOUS MIXER

Finer, faster blending for in-line processing



- **CUT PROCESSING COSTS:** This compact and completely self-contained unit conserves space, eliminates large mixing and paddle tanks, speeds up pipe line processing, handles high viscosity material in a minimum of time and conveniently lends itself to systems requiring jacketed heating or cooling.
- **ELIMINATE COSTLY EQUIPMENT:** Incorporating the same design principle as the portable SHEAR-FLOW, the new continuous mixer is capable of mixing any liquid that can be pumped, with results better than or comparable to that of equipment costing considerably more.
- **VERSATILE ADAPTABILITY:** More than one unit can be installed in series or in tandem along the route of flow. The new continuous SHEAR-FLOW can also be mounted either vertically or horizontally.
- **HI-SHEAR HEAD:** The unique Hi-Shear Head with dual impellers and stationary stators creates a high turbulence and concentrated shearing action that results in finer, faster blending, homogenizing, emulsifying or dispersing. Mechanical shear is achieved through close tolerances between impellers and stators.
- **SIZE RANGE:** The new SHEAR-FLOW can be powered with motors ranging from 1 to 10 horsepower depending on the power requirement demanded by the application.



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SHEAR-FLOW
GABB SPECIAL PRODUCTS INC.

GABB SPECIAL PRODUCTS INC.
Windsor Locks, Conn.

LITERATURE . . .

Construction Materials

Alloys.....Nine corrosion-resistant alloys are available to solve corrosion problems. Test samples and descriptive literature are available on request.
145 *Haynes Stellite Co.

Alloys.....Colmonoy alloys & methods can protect your equipment. The Spraywelder Catalog and the Colmonoy Hard-Surfacing Manual are available.
TL213 *Wall Colmonoy Corp.

Ceramic Cement.....Data sheet describes ceramic cement, type 64CP, used for bonding temperature or strain gage transducers to metallic or nonmetallic surfaces.
186A Trans-Sonics, Inc.

Coating.....No other process applies a hard, corrosion-resistant coating without the use of electricity as Kanigen does. Further information is available on request.
32 *General American Trans. Corp.

Coatings.....Nokorode coatings and their applications, uses and specifications are described in a technical booklet which is available on request.
4 *Lion Oil Co., Div. of Monsanto

Diatomite.....Celite offers a wide choice of grades each carefully controlled for complete uniformity. It is essentially nonhygroscopic. Tech. data.
46 *Johns-Manville

Insulating Varnishes.....8-page bulletin discusses technique for using properties of diallyl phthalate in coating, sealing, dip encapsulation and laminating applications.
186B Food Machinery & Chemical Corp.

Metal Primer.....A new heavy duty epoxy type high resistant metal primer contains lead silico chromate, iron oxide and leafing type pigment. Bulletin.
186C Wisconsin Protective Coating Corp.

Organic Peroxide Catalyst.....Bulletin describes types of organic peroxides, methods of vinyl polymerization and polyesters. Factors determining selection of catalysts are studied.
186D McKesson & Robbins, Inc.

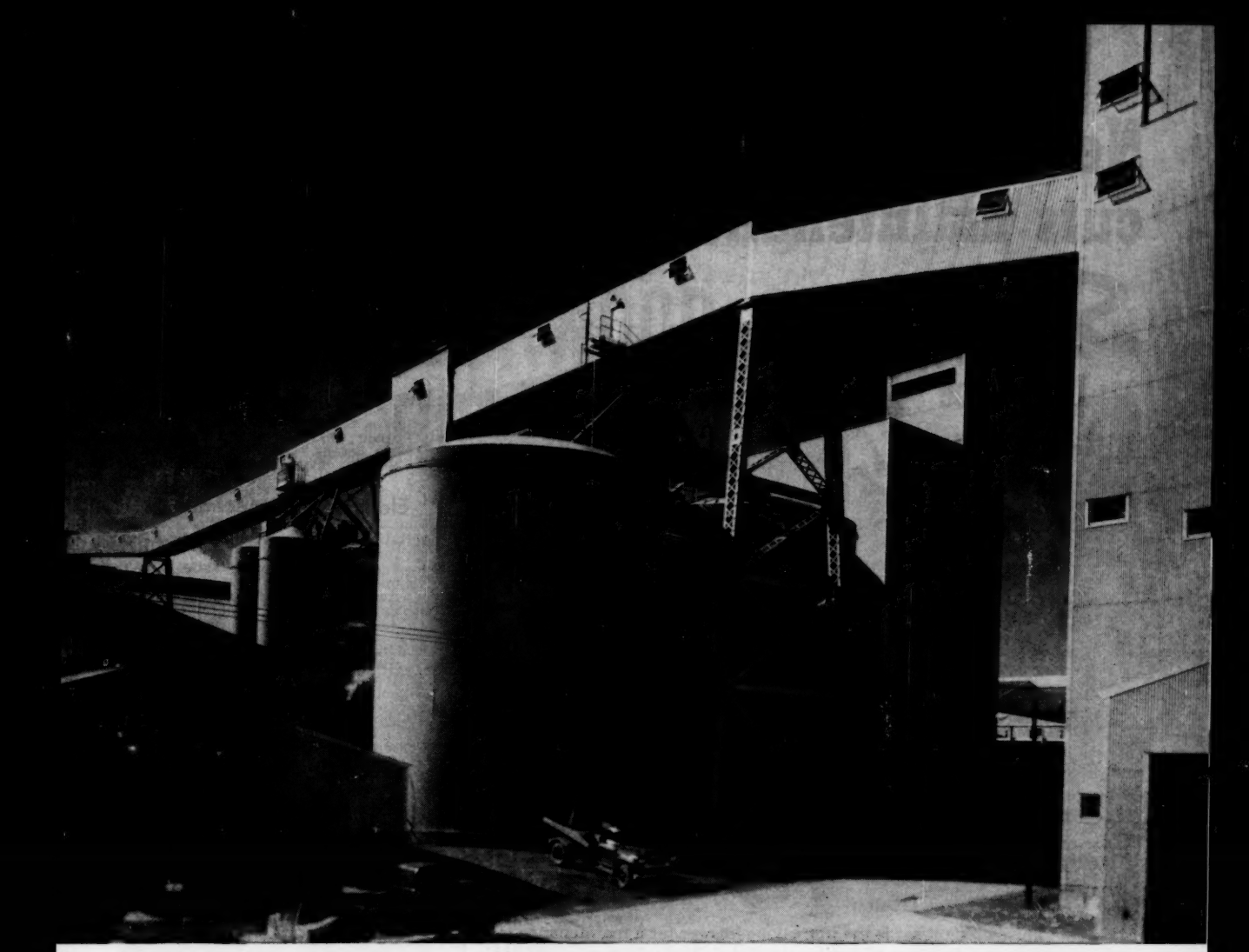
Packings.....For special conditions or for any other mechanical packings application there is a complete range of packing styles. Information in book PK-131A.
67 *Johns-Manville

Platinum Metals.....in all shapes and forms . . . sheet, strip, foil, wire, tubing, gauze, salts and chemicals. Clads & composities also available in many forms. Bulletin P-6.
143 *J. Bishop & Co.

Protective Coatings.....for steel tank linings, concrete floors, tank cars, etc. Selection of coatings & other Plasite Products covered in booklet.
L212 *Wisconsin Protective Coating Co.

Silicone Insulation.....A brochure, "Specify Silicone Insulation and Save" is available for information on the advantages of this insulation for electrical equipment.
149 *Dow Corning Corp.

* From advertisement, this issue



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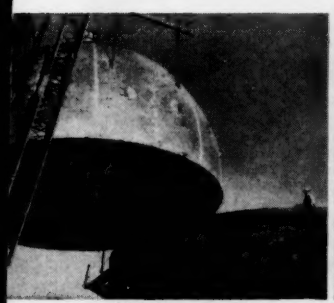
Structurals of REYNOLDS ALUMINUM

Plant upkeep is cut *substantially* with structurals and equipment of Reynolds Aluminum. Aluminum resists corrosion and weathering, even in the worst industrial atmospheres; it keeps its strength; it won't rust. Seldom, if ever, do you have to provide protective maintenance for aluminum buildings, fences, gratings, structurals, or equipment.

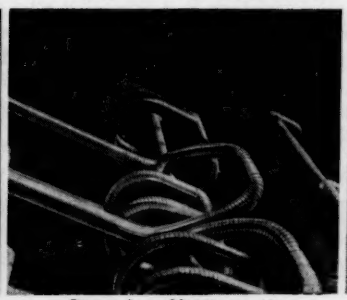
Thanks to the lightweight strength of aluminum, you can speed installation, reduce fabricating, shipping, handling, and erection costs. Aluminum requires less support, and it's non-sparking. For complete literature file, call your local Reynolds office or write *Reynolds Metals Company, P.O. Box 2346-CJ, Richmond 18, Virginia.*

REYNOLDS ALUMINUM FOR CHEMICAL PROCESSING



Low-Maintenance Tanks and Vessels

Low-Cost, Corrosion Resistant Process Pipe



Clean, Low-Maintenance Jacketing

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New all-wrench tool set cuts maintenance time

Snap-on

181-piece nut-turning set

SNAP-ON 5181-GS-B Set
181 tools in metal box

This SNAP-ON set is the timesaving answer for a maintenance man with a wide range of nut-turning jobs. The selection of 181 tools contains every standard wrench size from 3/16 to 1-7/8 in. Included are open-end wrenches, box wrenches, combination wrenches, flexible head wrenches, ratcheting box wrenches and socket wrenches.

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Tool chest embodies all the best SNAP-ON construction features — full-length, piano-type hinges; reinforced channel top; easy-sliding, no-sag drawers; close spot welding for added strength; double-rolled edges for rigidity; and strong trunk handles for lifting the chest.

Got a tool problem — ask your SNAP-ON sales engineer

The SNAP-ON sales engineer is a specialist who devotes *all of his time* to the industrial application of wrenches and mechanics' hand tools. He welcomes the opportunity to help you solve your assembly and maintenance tool problems. Write us for his name or call your nearest branch. Free catalog of industrial wrenches is yours for the asking.

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SNAP-ON TOOLS

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LITERATURE . . .

Stainless Steel.....Centrifugally cast stainless steel sleeves, liners, cored bar stock. All 13¼" long. 63 sizes ready to ship. Information on request.
R174 *The Vollrath Company

Zinc Coatings.....Inspection manual governing protective zinc coatings on products hot dip galvanized is designed to help manufacturers achieve optimum corrosion protection.
188A American Zinc Institute Inc.

Wire Cloth.....For corrosive service, cloth with accurate mesh count, close tolerance wire diameter, precision weaving, etc. Bulletin F-C has details.
193 *Newark Wire Cloth Co.

Electrical & Mechanical

Agitation Drive.....Bulletin describes features of drive designed to provide quiet, low-cost agitation in open or closed chemical vessels. Available with either seal or stuffing box.
188B Pfaudler Permutit Inc.

Bearings.....A broad line of widely distributed bearings of the right type and size for every need. All conditions and their combinations are met. Bearing Bulletin.
89 *Dodge Mfg. Corp.

Couplings.....are available in Brass, Malleable, Stainless, Aluminum, Monel, or other materials for corrosion resistance under any conditions. Illustrated Cat. C-11.
139 *Ever-Tite Coupling Co., Inc.

Drive System.....Varidyne system features coordinated start and stop control and explosion-proof A.C. motors. Further details are contained in Brochure F-1963.
215 *U. S. Electrical Motors, Inc.

Expansion Joint.....Teflon expansion joints solve heat and corrosion problems in vacuum drying operations. Technical literature is available to help with your problem.
194 *Raybestos-Manhattan, Inc.

Gearmotor.....has ratings ⅛ to 125 hp, in right angle, parallel or in combination. Right angle ratios are available in 96:1; parallel 120:1. Bulletin E2409 is offered.
16-17a *Reliance Electric & Engrg. Co.

Induction Motor.....Publication 1300-PRD-230 describes companies line of vertical, squirrel cage induction motors from 60 to 4,000 hp suitable for vertical pump drive.
188C Electric Machinery Mfg. Co.

Motodrives.....Reeves motodrives are used extensively for hundreds of production needs. Available in hundreds of space-saving assemblies. Bulletin M-592.
16-17c *Reliance Electric & Engrg. Co.

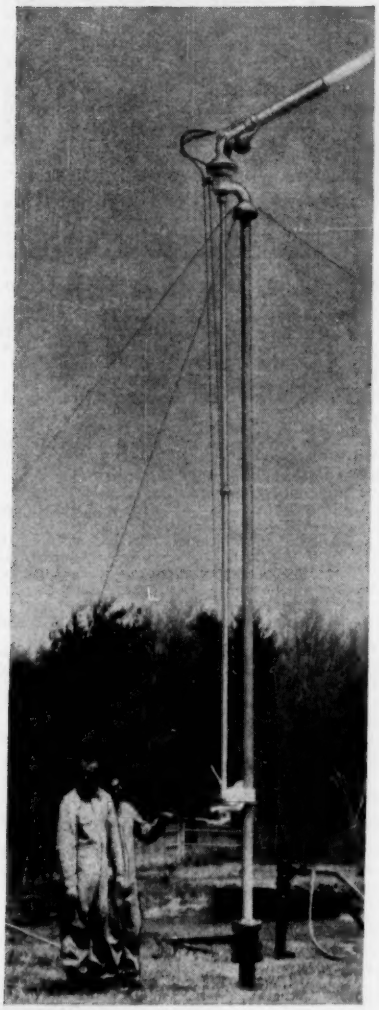
Motor.....Encapsulated motor gives you positive protection from dust, dirt, acid and water. Maximum flexibility tensile & bond strength. Further information in Bulletin B-2108.
16-17b *Reliance Electric & Engrg. Co.

Thermocouple Assemblies....More than 100 complete assemblies in a wide range to cover most applications in any industry. Details are available in Catalog G100-1.
R213 *Minneapolis-Honeywell

* From advertisement, this issue

Fight fires from any angle...
WITH ROCKWOOD SPECIALTY TURRET NOZZLES

Getting The Upper Hand...



Rockwood Extended Manual Control Turrets can be located 10 to 20 feet above a remote control station on the ground. Greater discharge range increases their fire fighting coverage. Higher extensions are engineered for special applications.

On the ground, on trucks, or towering over the flames, Rockwood Turret Nozzles are valuable fire fighting aids for use in refineries and chemical plants.

In fact, Rockwood makes the most complete line of specialty turret nozzles on the market. Every type is designed to fight fire four ways: with solid FOAM stream, FogFOAM, WaterFOG or solid water stream. And all are easily adjustable to meet changing fire conditions.

Throughout the country these Rockwood advancements are proving they can hit fires harder and faster. Find out how well they can protect your own plant. For an illustrated booklet on this complete line, write to Rockwood Sprinkler Company, Portable Fire Protection Department, 529 Harlow St., Worcester 5, Mass.

ROCKWOOD SPRINKLER COMPANY

A Division of The Gamewell Company
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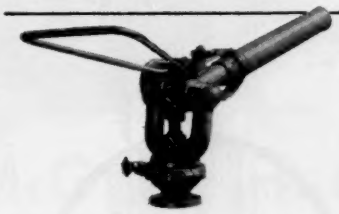
Engineers Water
...to cut fire losses

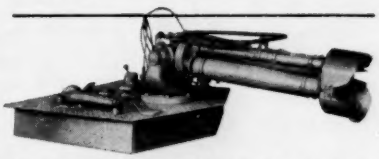
Distributors in all principal cities

Fighting Fires Four Ways

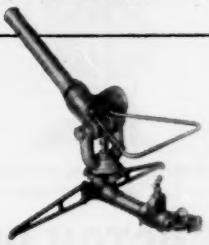


Rockwood Direct Manual Control Turrets give fire fighters "on deck" control from their cab roofs.

A Remote Manual Control Turret is easily handled by a man in the driver's seat. Ideal for fast action.

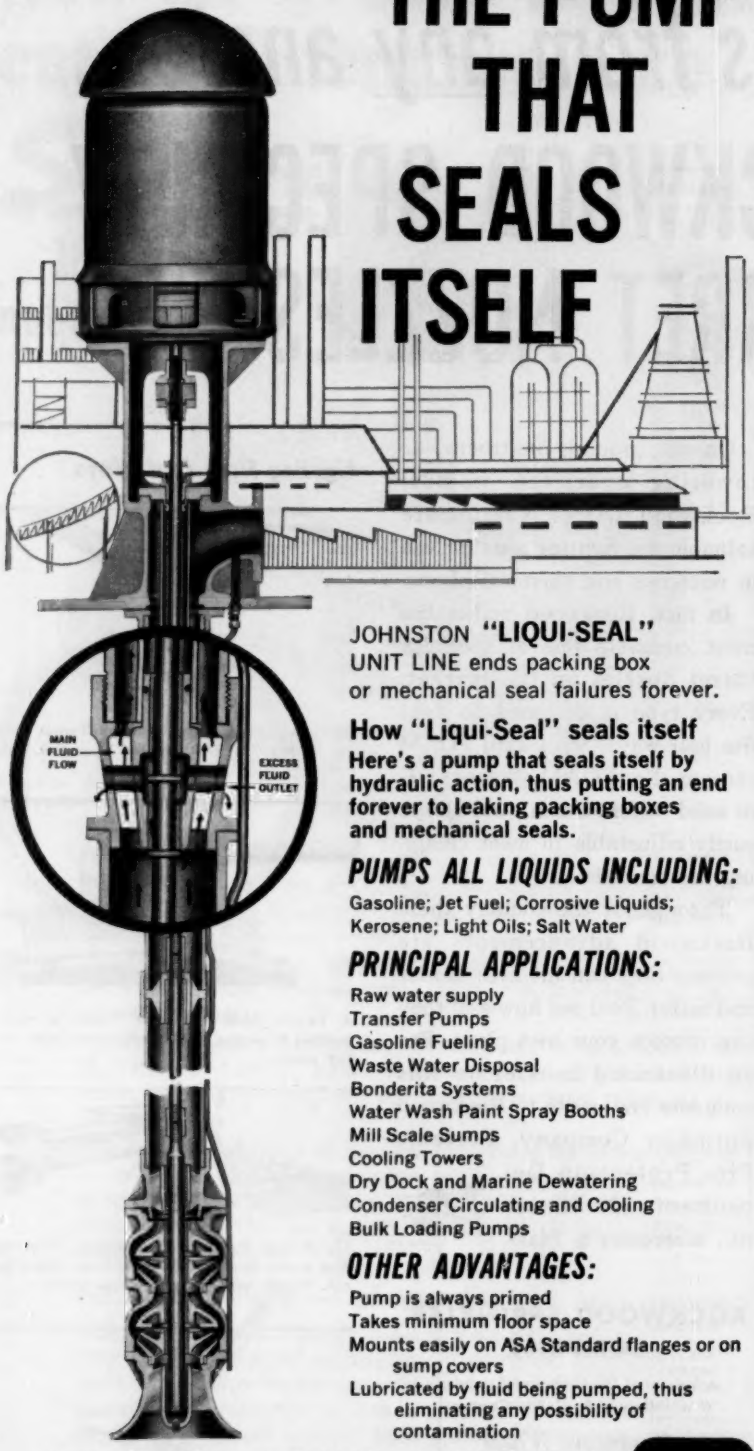


The Remote Hydraulic Control Type, single or dual model, is power controlled from within the cab. Widely used on crash rescue trucks.



The Portable Type goes off the truck and into action in seconds – wherever hose lines can be brought into action.

THE PUMP THAT SEALS ITSELF



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UNIT LINE ends packing box or mechanical seal failures forever.

How "Liqui-Seal" seals itself

Here's a pump that seals itself by hydraulic action, thus putting an end forever to leaking packing boxes and mechanical seals.

PUMPS ALL LIQUIDS INCLUDING:

Gasoline; Jet Fuel; Corrosive Liquids; Kerosene; Light Oils; Salt Water

PRINCIPAL APPLICATIONS:

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Mill Scale Sumps
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Dry Dock and Marine Dewatering
Condenser Circulating and Cooling
Bulk Loading Pumps

OTHER ADVANTAGES:

Pump is always primed
Takes minimum floor space
Mounts easily on ASA Standard flanges or on sump covers
Lubricated by fluid being pumped, thus eliminating any possibility of contamination

For complete details contact your nearest Johnston Distributor or write direct to the factory for colorful bulletin.

JOHNSTON PUMP COMPANY

3272 E. Foothill Blvd., Pasadena, Calif.

LITERATURE . . .

Turbines.....built to customers' specifications, including API and NEMA standards. A complete range from 1 HP to 250 HP. Further facts in Catalog 200.
31 *Coppus Engineering Corp.

Handling & Packaging

Air Vibrators.....Easy to install, units will operate in hazardous atmospheres, inclement weather or magnetic dusts. Application catalog offered.
BL197 *National Air Vibrator Co.

Bagging System.....This bin-to-bag system includes a screw feeder, an automatic gross weigher, a bag conveyor & a sewing pedestal. A technical bulletin is available.
164 *Richardson Scale Co.

Gas Transports.....Extreme mobility & economical storage make Taylor-Wharton gas transports ideal for bulk transportation of compressed gases. Information.
26 *Harrisburg Steel Co.

Liquid Handling.....12-page booklet contains complete speech entitled "Liquid Handling As Related to Mixing" presented at the 1960 Feed Production School.
190A Sprout, Waldron & Co., Inc.

Loader.....Loads can be palletized or stacked in any pattern, also put into warehouse storage. Literature and engineering details are available.
BL195 *Power-Curve Conveyor Co.

Payloader.....Model H-25 Payloader offers extraordinary protection such as cartridge-type oil filters. A booklet "Industrial Materials Handling from A to Z" is offered.
79 *The Frank G. Hough Co.

Scales.....have no knife edge pivots to wear and cause inaccurate weighing. Recommendations on improving or maintaining your competitive position are offered.
R200 *Thayer Scale Corp.

Tanks.....Poxyglas tanks are 3 to 4 times as strong as conventional reinforced plastic tanks. Lighter than welded steel tanks. Corrosion-resistance chart is offered.
71 Black, Sivalls & Bryson

Tanks and Vessels.....4-page brochure describes pressure tanks and vessels. Models, engineering drawings and representative dimensional tables are included.
190B Cutler Metal Products Co.

Weighing Systems....a major cost control tool. Weight records directly affects costs, quality control, inventories and customer billing. Bulletins 2036 & 2017.
172 *Toledo Scale Corp.

Heating & Cooling

Aeration System.....The theory, techniques, equipment & economics of low pressure aeration or water & sewage are fully developed in a 56 page report, Tech. Reprint 56.
190C Dorr-Oliver, Inc.

* From advertisement, this issue

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American controlled capacity proportioning pumps have repetitive metering accuracy of plus or minus 1%, when operating between 10% and 100% of capacity. Feed precisely metered fluids or slurries in virtually all ratios, with flow, temperature, pressure, conductivity, pH and other controlled process variables.

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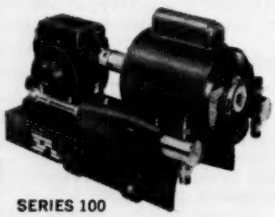

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LITERATURE . . .

Boilers.....Positive Flow boiler is the greatest advance in packaged fire-tube boiler design in seven decades. Complete information is available in Bulletin 1275.
83 *Orr & Sembower, Inc.

Cooler.....Roto-Fin's design is simple with minimum number of moving parts for continuous, trouble-free operation. No fans, collectors or elaborate controls are required.
23 *Link-Belt Co.

Dryers & Heaters.....Dry without contamination from combustion gases, regardless of fuel. Collect vapor at high concentration. Complete specifications in Bul. AH-438-11.
198 *Hardinge Co., Inc.

Evaporator.....constructed with stainless steel and Hortonclad stainless on areas subject to corrosion and embodying high standards of fabrication for minimum maintenance.
153 *Chicago Bridge & Iron Co.

Heat Exchanger.....New C-200 heat exchanger for industrial or process heating or cooling. Assembled to your order from fully standardized components. Bul. 301.7K1.
89 *American-Standard

Heat Exchangers.....Bulletin discusses features of two standard exchangers with straight tubes, externally packed floating tube sheets, removable bundles and single or two-pass design.
192A American-Standard

Heat Transfer.....Platecoil saves on engineering, fabricating and installing in comparison with pipe coils. Greater heat transfer capacity permits compact units. Bul. P61.
30 *Patecoil Div., Tranter Mfg.

Packaged Boilers.....Sizes through 600 hp...oil, gas and combination oil-gas firing...larger sizes in Springfield water-tube boilers. Booklet "How to Select a Boiler."
40 *Cleaver-Brooks Co.

Steam Traps.....A 48-page book tells how to correctly size, install & maintain steam traps for any pressure, temperature or load. Additional data in Catalog K.
169 *Armstrong Machine Works

Steam Traps.....Thermostatic steam traps operate on a true balanced vapor-pressure principle, they discharge air, condensates & other non-condensables. Cat. 400.
159 *W. H. Nicholson & Co.

Instruments & Controls

Analyzers.....LIRA Model 200 infrared analyzers are automatic and continuous. Helpful literature is available for help with your process steam problems.
173 *Mine Safety Appliances

Computer.....Recomp 11 has exclusive built-in floating point arithmetic. Also features built-in square root command and automatic conversion from decimal to binary.
133 *Autonetic Div., N. Amer. Avia.

Controller.....Multi-Point controller controls ten process temperatures. Critical circuitry is fused against overloading. Maintenance is easy. Instrument Sec. 52-4 offered.
34 *Thermo Electric Co.

* From advertisement, this issue

Controls.....Handbook, "Modern pH and Chlorine Control" gives theory and application of pH control. Illustrates & describes full line. Available on request.
L210 *W. A. Taylor & Co.

Controls.....The Massometer is calibrated with any maximum output between 40 & 200 lbs. per minute. Maximum volumetric capacity is 6 cubit ft. per minute. Details.
150 *Wallace & Tiernan Inc.

Data & Control Equipment.....A brochure is offered describing the features of equipment control systems, quality control and accounting and digital data systems.
193A Datex Corp.

Flow Test Kits.....Four variable-area flowmeter kits, each containing meters of various sizes for a wide range of flow measurements, are described in a 4-page bulletin.
193B *Fischer & Porter Co.

Flow Transmitter.....New Bellows flow transmitter is available with a concentric scale or as a nonindicator. It has 16 ranges from 0-10 in. to 0-400 in. of water.
24 *Minneapolis-Honeywell

Flowmeter.....A miniature magnetic flowmeter designed for flow rates as low as 10 cc/minute with an accuracy of 1% of full scale is described in Specification Bulletin 10D1415A.
193C Fisher & Porter Co.

Gages.....Information on Acragage pressure, vacuum, compound and test gages and electric and pneumatic transmitters and receivers is available in Bulletin EC-761.
161 *Robertshaw-Fulton Controls

Gas Chromatograph.....Brochure describes instrument with a detection system of the thermal conductivity filament type and a fast response full-flow cell geometry.
193D Beckman Instruments Inc.

Gauges.....A complete catalog describing gauges for use in refineries and chemical plants is available on request. Includes a wide variety of types.
L174 *Strahman Valves, Inc.

Liquid Level Control.....is available for controlling level changes from ⅛" to 150 ft. Multi-stage switching when desired. Information on Magnetrol on request.
TR214 *Magnetrol, Inc.

Liquid Level Control.....Sono-Switch works on all liquids, has no moving parts. It is corrosion-proof, acceleration proof and highly accurate. Literature is offered.
179 *Powertron Ultrasonics

Meters.....Niagara meters simplify handling and control of corrosive & standard liquids. For use with any liquid from water to solvents to sulfuric acid. Bulletin 48.
180 *Buffalo Meter Co.

Negative-Ion Generators.....8-page well detailed technical booklet explains how to build negative-ion generators and how to measure their ion output. Charts and diagrams included.
193E Westinghouse Electric Corp.

pH System.....The new pH Dynalog Recorder has an input impedance of 80,000 megohms—eliminates the need for intermediate amplification. Data sheet offered.
129 *The Foxboro Co.

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If you have a tough corrosion problem and need wire cloth or wire cloth parts, here's a source of supply that knows the answers. We are proud of the quality of our cloth...accurate mesh count, close tolerance wire diameter, precision weaving...plus the know-how necessary to specify the proper alloy for your service conditions.

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Newark Wire Cloth COMPANY

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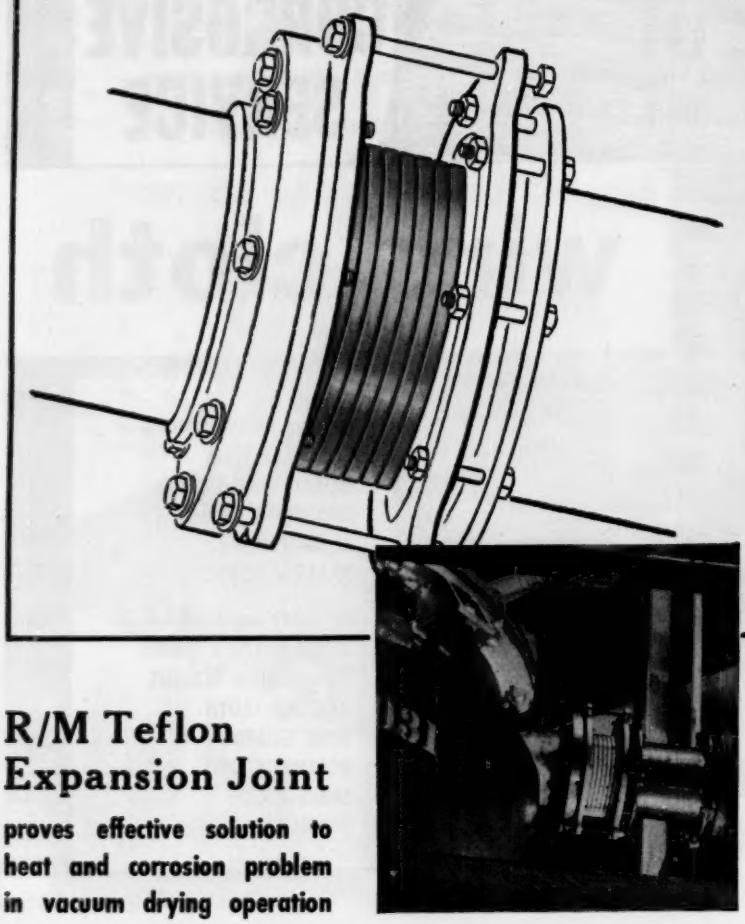

R/M Teflon Expansion Joint

proves effective solution to heat and corrosion problem in vacuum drying operation

When an expansion joint was needed for high-temperature service on a vapor connection in a vacuum drying operation used in making dyes, the Toms River Chemical Corporation, of Toms River, N.J., turned to R/M. Result: An R/M machined Teflon* joint. Not only did the joint stand up to operating temperatures of 210-220°F, but it also resisted corrosion due to the various chlorides in the system.

R/M selected Teflon for the application for several important reasons. Teflon has excellent heat stability and is virtually impervious to attack from or reaction with all but a few known chemicals. Teflon has excellent nonadhesive properties.

Toms River Chemical Corporation realized other advantages, too. Machining to close tolerances with uniform wall thickness provides maximum resistance to fatigue and vibration. And an adjustable tie rod limit bolt arrangement prevents overexpansion of joints.

R/M, as a major producer of mechanical packings and gasket materials for industry, has the experience and capability to help solve your packing problem. Write for technical literature.

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MECHANICAL PACKINGS AND GASKET MATERIALS

LITERATURE . . .

Radiation Thermometer.....Model TD1 measures temperature without physical contact. Time is constant and the temperature range is 100 deg. F. to 8000 deg. F.
194A Radiation Electronic Co.

Recorder.....Dependability is assured with the 202A flow recorder. It is compact and ruggedly built and has built-in overrange protection. Bulletin 202A-1 is offered.
170 *Barton Instrument Corp.

Recorder.....Model 5 multipoint strip chart recorder and its advantages and applications are described in Bulletin 190 which is available on request.
194B Westronics, Inc.

Temperature Indicators.....Various models and their many features and characteristics are contained in Publication 3023B which is available.
194C Thomas A. Edison, Inc.

Viscometers.....for polymerization and other similar processes. Viscosity is accurately measured and automatically recorded. Bulletin V1218 is available on request.
194D Norcross Corp.

Pipe, Fittings & Valves

Ball Valve.....Flo-Ball offers top entry, in-line maintenance, top & bottom guided ball, double seats, flanges integral with body and other features.
141 *Hydromatics, Inc.

Ball Valves.....with the exclusive tapered cartridge that drops out for fast, in-line servicing. Engineered for corrosion resistance plus tight shutoff.
155 *Crane Co.

Ball Valves.....Double-Seal ball valves are available in a wide variety of materials for many applications and are made in a number of sizes for maintenance-free operation
69 *Jamesbury Corp.

Butterfly Valves.....Resilient seated butterfly valves save space, save weight, save cost and save trouble. Control may be manual or automatic. Bulletin 590X.
R212 *W. S. Rockwell Co.

Control Valves.....Catalog B-1 is available for complete data on these versatile valves for positive control of your problem fluids.
TL197 *G. W. Dahl Co.

Fittings.....Aluminum copper free fittings engineered to give added strength at stress points include unilets, junction boxes, accessories, etc. Bulletin AL-60.
194E Appleton Electric Co.

Fittings.....Conoseal union fittings for highest performance when joining all types of small diameter tubing. Further information in Bulletin 804 which is offered.
156 *Marmon Div. Aeroquip

Glassed Metal.....Pipe, valves and fittings are covered in bulletin that tells importance of glassed metal pipe and accessories in installations that require corrosion resistance.
194F Pfaudler-Permutit Inc.

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NO LUBRICATION
NO CONTAMINATION
NO MAINTENANCE

SULZER
NON-LUBRICATED RINGLESS
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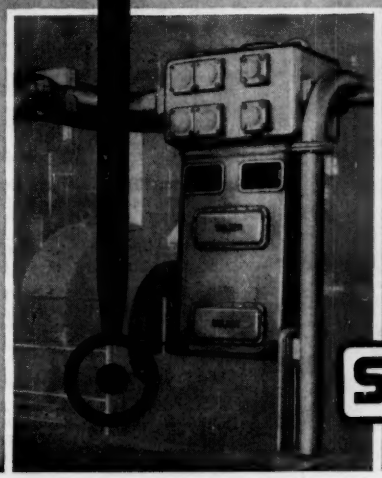
Assures Absolute Contamination-Free Compression Of Dry Or Moist Gases!



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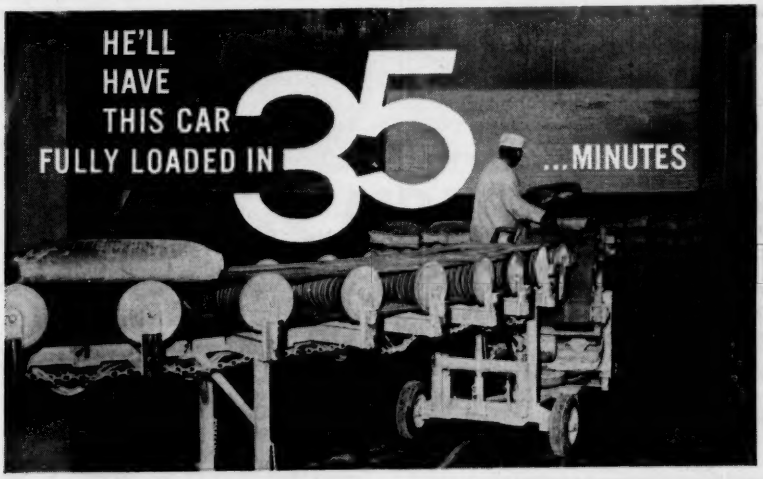

...without help, using a POWER-CURVE Loader

Bag loading costs of eight cents a ton are not uncommon in plants using Power-Curve equipment. One man loads and stacks direct from the packer with no need to lift a single bag. Loads can be palletized or stacked in any pattern, also put into warehouse storage.

There are Power-Curve installations near you. Let us show you how your plant can benefit from a custom engineered Power-Curve loading operation.

Literature and engineering details sent on request.

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Select from over 3,500 different
SOLENOID VALVES
from
VALCOR

Series SV-54 (3 way-4 way) general purpose solenoid valves for air, oil and water. Rugged construction, yet inexpensive. Multi-million cycle life. Pressure ratings up to 150 psi. Nylon seat outlasts steel. Infinite varieties available... lists as low as $10.75.

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Series SV-5100 Specifically designed to handle the most corrosive media in industry. Manufactured in Teflon, PVC and Nylon varieties. Diaphragm construction prevents media contact with any metal. Available in direct-acting or piloted models.

FREE... new 16 page brochure—lists over 500 corrosive media—coded for correct valve selection.

For complete information on these or other models, write or call:

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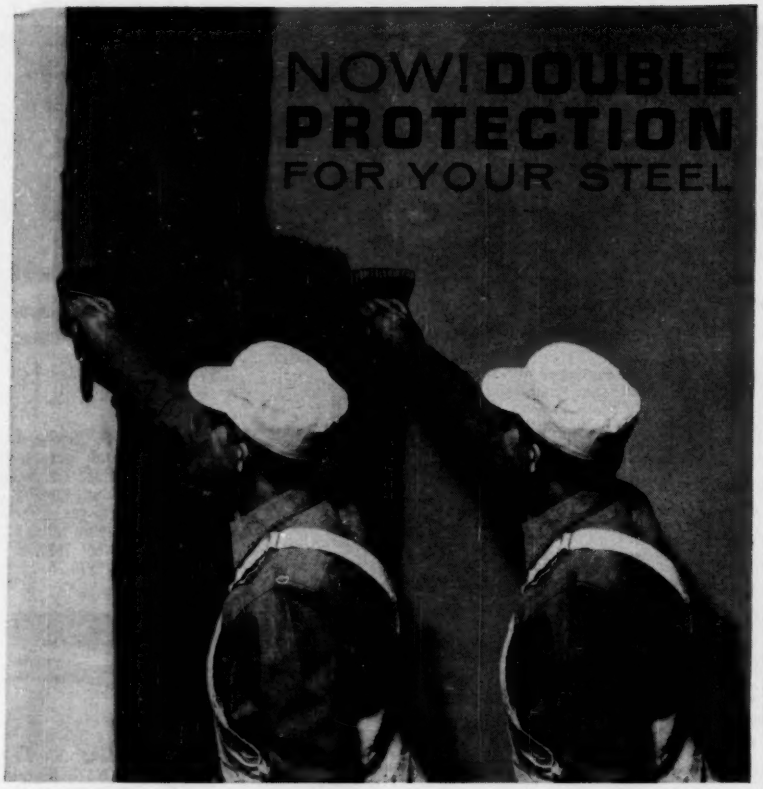

CARBO ZINC 11* *as a primer—*

protection continues even after topcoats are penetrated

Carbo Zinc 11 is an inorganic zinc-filled coating which gives protection similar to galvanizing. It is used either as a lining, a one-coat maintenance system, or a primer with color topcoats.

You can topcoat Carbo Zinc 11 in color with any of these generic types: epoxy-ester, catalyzed epoxy, vinyl, Hypalon, chlorinated rubber. Choose the correct topcoat that meets your chemical or weathering exposure requirements—and upgrade your present protection.

Sacrificial properties of Carbo Zinc 11 prevent undercutting or subfilm corrosion if surface is penetrated. This exclusive characteristic protects and lengthens system life 2-3 times. You save money by reducing repainting cycles.

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*Patent applied for

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MAINTENANCE COATINGS WITH EXPERIENCE

LITERATURE . . .

Needle Valves.....Three great series, alloy steel, stainless steel and 416 stainless steel are available. In a full range of sizes and patterns including panel mounted.
B201 *Marsh Instrument Co.

Nozzles.....Turret nozzles fight fires from any angle. Every type is designed to fight fire four ways: with solid FOAM, FogFOAM, WaterFOG and solid water stream. Bklt.
189 *Rockwood Sprinkler Co.

Pinch Valves.....New system for automatic opening and closing of pinch valves consists of one or more valves with a single automatically operated hydraulic pump. Bulletin available.
196A Mine and Smelter Supply Co.

Pipe.....Data on Fluoroflex-lined steel pipe is offered. Features no corrosion, no leakage. Comes in sizes & lengths specified in your piping plan.
29 *Resistoflex Corp.

Polyethylene Pipe.....Bulletin discussing polyethylene pipe should help the plant engineer understand the quality, type, density and proper application of this useful product.
196B Union Carbide Plastics Co.

Pressure Tubing.....Electricweld tubing is made of the finest carbon steel. Provides uniform outside diameter, wall thickness and concentricity.
81 *Jones & Laughlin Steel Corp.

Steel Valves.....Hancock steel valves provide the dependable protection demanded for every process application. Further information in Catalog 200A.
6-7 *Manning, Maxwell & Moore

Swivel Joints.....for practically all petrochemical & chemical services. Sizes from ⅜" to 12" diameter in steel & from 2" to 12" diameter in aluminum. Catalog.
137 *Continental-Emsco Co.

Tube Expanders.....New Tube expanders roll tubes into thick sheets in one pass. Bul. Y-52 outlines the complete line of retubing accessories plus tube expanders.
168 *Elliott Co.

Tubing, Pressure.....Seamless tubing is available in all common carbon, alloy & stainless grades, up to 11" O.D. and with wall thickness up to 3¼".
39 *Timken Roller Bearing Co.

Valve.....Sleeveline valves are designed & priced to replace ball valves, gate valves & lubricated plug valves wherever they are in use. Bulletin V/12a.
135 *The Duriron Co.

Valve, Ball.....The Econ-O-Miser is available from ¼" through 6" size range & is ideally suited to difficult media because of its smooth round flow & quarter-turn operation.
33 *Worcester Valve Co., Inc.

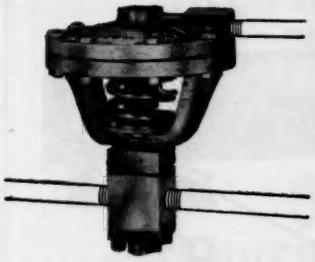
Valves.....16-page bulletin describes and illustrated complete line of corrosion-resistant valves and includes summarization of types of alloys available in different valves.
196C Alloy Steel Products Co.

Valves.....Offer quick action, leakproof seal, minimum pressure drop, straight through full flow, self grinding rotating disk. Informative bulletins give details.
97 *Everlasting Valve Co.

* From advertisement, this issue

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

POSITIVE CONTROL FOR PROBLEM FLUIDS!



If suitable barstock material is available, any problem fluid can be throttled or provided with positive on-off control. Dahl BANTAM Control Valves, featuring barstock bodies, handle any chemical fluid except liquid metals like sodium and similar fluids where excessive temperature is a restriction.

BANTAM features include excellent flow characteristics, low hysteresis, and fast response. Offered in a wide selection of pneumatic operators and control positioners, standard models are rated at pressures up to 1000 psi at 450°F. Compactness, quality construction, and ruggedness also contribute to their virtually unlimited application versatility.

REQUEST Catalog B-1 for complete data on these versatile valves . . . for positive control of your problem fluids! G. W. Dahl Co., Inc., 84 Tupelo Street, Bristol, Rhode Island.

G. W. DAHL CO., INC.

SPECIALISTS IN COMPACT VALVES AND CONTROLS

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"LONG-STROKE"

AIR VIBRATORS

Move Materials on BINS • HOPPERS • CHUTES

Navco "Long-Stroke" Air Vibrators dislodge arched material with a timed piston impact . . . do not "pack" materials with high frequency vibration. Exclusive patented "one-piece" design eliminates body assembly bolts, cuts vibrator maintenance up to 80%. Easy to install, units will operate in hazardous atmospheres, inclement weather or magnetic dusts.

For application catalog, write Dept. CE-3

NATIONAL AIR VIBRATOR CO.

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Navco vibrators on exterior bins keep wet and frozen material moving at this Wisconsin plant. Solenoid valve gives automatic operation and control of bulk material.

Take Guesswork Out of Lab Crushing & Grinding

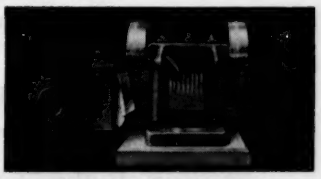
Sturtevant Design Provides Easy Access for Cleanouts — Returns Complete Sample

In seconds, because of "Open-Door" accessibility, all Sturtevant crushing or grinding parts are exposed for thorough cleanouts. 100% sample return is easy to secure.

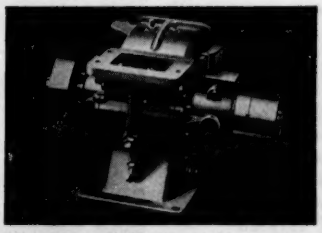
Sturtevant laboratory machines are ruggedly constructed — design, based on production models, gives top lab or pilot performance.

Send for Bulletin No. 067, which gives full description of all Sturtevant laboratory machines.

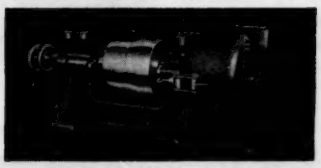
Lab Crushing Rolls: Special lab design. Two models: 8 x 5 in. and 12 x 12 in. rolls. Capacities to 10 tph. Both models adjust down to 20 mesh. Tires of high carbon forgings. Automatic feeder, adjustable controls.



Lab Jaw Crusher: Crushes hardest rocks at ½ to ⅛ in. settings. Roll jaw action — no clogging. Feed opening 2 x 6 in. Capacity to 1900 lbs. per hr. at ½ in. setting. Instant adjustment. Manganese jaws, reversible shield.



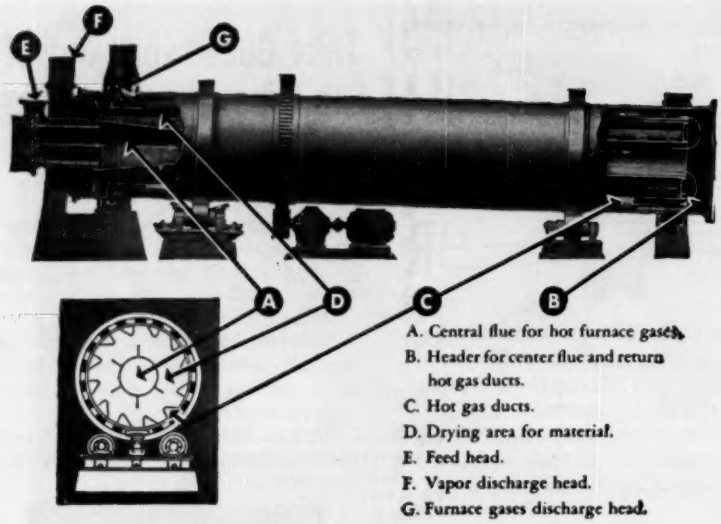
Lab Swing-Sledge Mill: 5 x 6 in. opening takes soft, medium, tough or fibrous feed. Capacity to 1 tph. Fines regulate from 1 in. to 20 mesh. Choice of gratings, hammers (or knives).



Sample Grinder: Disc type grinders for dry, friable soft or medium materials. Three sizes — 6 in., 10 in., and 14 in. take feed as coarse as ¼ in. Produces 100 mesh fines at capacities to 200 lbs. per hr. on largest model. Regulate 10 to 100 mesh. In-operation adjustment.

STURTEVANT MILL COMPANY

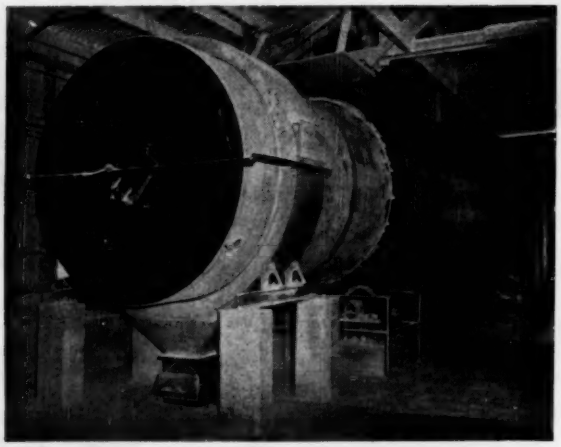
100 Clayton St., Boston 22, Mass.



A. Central flue for hot furnace gases.
B. Header for center flue and return hot gas ducts.
C. Hot gas ducts.
D. Drying area for material.
E. Feed head.
F. Vapor discharge head.
G. Furnace gases discharge head.

Ruggles-Coles INDIRECT-FIRED DRYERS and HEATERS

- Dry without contamination from combustion gases, regardless of fuel.
- Minimize auxiliary dust collection when handling fine precipitates and filter cake.
- Heat pulverized materials for process work.
- Collect vapors at high concentration.
- Available fabricated with heat and corrosion-resistant metals.



104" diameter by 65' long Ruggles-Coles Indirect Dryer removing moisture from washed and filtered Kaolin clay at Gardner, Ga., plant of Mineral and Chemical America, Edgar Division.

Write for complete specifications. Ask for Bulletin AH-438-11

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LITERATURE . . .

Valves.....Corrosion-Resistant valves are available in a wide selection of materials, to handle practically every known corrosive media. Details on request.
75 *The Wm. Powell Co.

Valves.....L Series solenoid valves feature forged naval brass bodies, stainless steel and brass internal parts. Catalogs are available for more complete information.
198A The Skinner Chuck Co., Elec. Valve

Valves, Fittings, Unions.....Stainless and alloy steel materials are shown in their application to specific types of piping products in the 432 page Catalog F-10.
98 *Henry Vogt Machine Co.

Valve, Butterfly.....Available in 4" to 72" sizes with manual or power operator and in any castable alloy. Further information in Bulletin 82.
B199 *Fisher-Governor Co.

Valves, Check.....Basic-Check unit is the simplest check valve you can use with tanks. Design simplicity assures long service life. Information in Bulletin CE-31.
160 *Durabla Mfg. Co.

Valves, Lubricated Plug.....available in either full or reduced port; rectangular, round, diamond & V-ports; also venturi, multiport & steam jacketed models. Cat. 400.
43 *W-K-M Div. of ACF Industries

Valves, Pinch....Massco-Grigsby pinch valves have patented "hinge" sleeve and patented Flex Seal ends. No working parts in contact with pulp or fluid. Cat. 609.
166 *Mine and Smelter Supply Co.

Valves, Solenoid.....Complete information on all models available. Also a 16-page brochure which lists over 500 corrosive media...coded for correct valve selection.
R195 *Valcor Engineering Corp.

Valves, Stop.....Series MGV stop valves feature high tensile alloy steel, removable & reversible seats, nonrotating stem, compact design for ease of maintenance. Information.
176 *McCartney Mfg. Co.

Process Equipment

Agitators & Mixers.....Turbine-type propeller (to 120" in tanks to 50" dia.) slow speed, high speed, air lift, vertical turbine mixers, mixer-settler units. Bul. A2-B2.
152a *Denver Equipment Co.

Air Separators.....Whizzer air separators offer sharper separation, added strength and stability and new economies in operation and maintenance. Bulletin 76.
96 *Combustion Engineering Inc.

Attrition Scrubbers.....High power input to efficiently remove sand coating, mix dense slurries. Rubber lined or acid-proof tanks. Sizes to 56" x 56". Bul. A-8505.
152b *Denver Equipment Co.

Centrifugals.....features no crystal degradation. All cycle components are pneumatically operated. Full information contained in Bulletin No. 2775.
185 *The Western States Machine Co.

* From advertisement, this issue

Crushers.....Horizontal saw tooth and vertical cone crushers are described in bulletin C-360A that provides full design and dimensional data on ten different models.
199A Young Machinery Co. Inc.

Crystallization Equipment.....offers high product purity, controllable & uniform crystal size and other advantages. A 16 page engineering booklet is available.
37 *Struthers Wells Corp.

Dissolver..... Aluminum vessel on Model 8-TV is 100" deep x 80" dia., 1500 gal. capacity, sealed against fume leakage and also sealed in floor. Further information offered.
47 *Morehouse-Cowles, Inc.

Dryer.....The Rotary Steam Tube Dryer in size 8'-0" x 45'-0" is described in Catalog "A". Also covers your Pressing, Drying and Cooling problems in detail.
BR214 *Davenport Machine & Foundry Co.

Dryer.....Budget Lectrodryers are ideal for any installation requiring small quantities of dry air. Data sheets citing solutions to moisture problems are offered.
163 *Pittsburgh Lectrodryer

Dryer.....Turbo-Dryers are available in a wide range of sizes from packaged pilot plants with a 60 sq. ft. area to giant outdoor units with 18,000 sq. ft.
85 *Wyssmont Company, Inc.

Dust Collector.....Because it has no moving parts—internally or in the gas stream—the Mikro-Pulsaire has proved ideally suited to handling abrasive materials.
35 *Mikro-Products

Feeding Systems.....Continuous feeding/blending saves material, reduces costs, controls quality & results in bigger processing profits. Facts booklet offered.
L175 *B-I-F Industries

Filter.....With the Eimco Belt filter, operation is continuous, with no blinding and no fall-off in filtration rate. Bulletin F-2053 is offered.
Cover *The Eimco Corp.

Filter.....Model VR 17-33 filter offers 100 sq. ft. filtering area and exclusive scavenger plate feature. Other sizes are available. Technical bulletins are offered.
38 *Sparkler Mfg. Co.

Generator.....Nitro-Gen generator can produce gases of oxidizing & reducing characteristics by varying gas/air ratio. Further details are avilable in Bul. 5901-N1.
L214 *C. I. Hayes, Inc.

Hydraulic Systems.....Packaged hydraulic systems assure faster, more reliable process control. Bulletin 15802, "Packaged Hydraulic Systems for Process Control" is offered.
147 *Vickers Inc.

Jaw Crusher.....with cast steel frame, anti-friction side bearings and bumper bearings are covered in detail in Bulletin C12-B12. Sizes from 2¼" x 3½" to 36" x 48".
152d *Denver Equipment Co.

Kilns & Dryers.....Specially designed, directly fired or indirectly heated, rotary kilns, dryers, roasters, ovens, calciners. Illustrated catalog shows unusual installations.
C213 *Posey Iron Works Inc.

*From advertisement, this issue

ONE PUMP FILLS TIN CANS OR TANKERS

Vari-Flo changes capacity instantly

Do you have pumping jobs that vary from a "dribble" to a "gusher"? Then you should learn about Blackmer Vari-Flo . . . the new variable-capacity pump that might do the job several pumps are doing for you now. The Vari-Flo is much like other Blackmer vane-type rotary pumps with the important addition of a dial-operated "flow changer". Works with an ordinary standard motor, too . . . no costly variable-speed drive needed. Whether you're filling a tin can or a tanker, you can dial the proper flow rate as easily as phoning your Blackmer distributor. Give him a call or write for Bulletin 600 if you see a chance for an application.

"liquid materials handling"® equipment

BLACKMER / *vari-flo pumps*

BLACKMER PUMP COMPANY, GRAND RAPIDS 9, MICHIGAN

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At High Pressures and High and Low Temperatures . . .

Here's a low cost, lightweight valve that cuts leakage to ⅕ or ⅓ of standard leak factors for metal seat valves. Assures reduced leakage at pressures as high as 6 000 psi with drops to 1200 psi, and temperatures from −300°F to +1500°F! Ideal for controlling fluids not compatible with rubber. Available in 4" to 72" sizes with manual or power operator and in any castable alloy.

FISHER-CONTINENTAL
PISTON RING BUTTERFLY VALVE

WRITE TODAY FOR BULLETIN 82

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD...CHANCES ARE IT'S CONTROLLED BY...
FISHER GOVERNOR COMPANY
Marshalltown, Iowa / Woodstock, Ontario
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BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIP. CO., CORAOPOLIS, PA.

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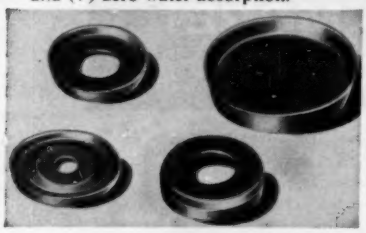
Dixon's new post-forming technique makes use of Rulon's plastic memory to insure tight seals under all conditions . . . at lower cost than ever before!

Packings of Rulon (filled TFE) give you: (1) low friction, (2) high resistance to wear, (3) low deformation under load (½ that of Teflon*), (4) wide temperature tolerance (−400° to +500°F), (5) chemical inertness, (6) lube free operation, and (7) zero water absorption.



RULON now serves in pumps, valves, motors, compressors and scores of other products manufactured by leading companies across the nation. Dixon offers the widest variety of basic shapes, both in RULON and Teflon . . . plus engineering capability to formulate special reinforced fluorocarbons for special needs. Also, Dixon can supply molded, machined, stamped, cut or extruded parts to meet your print.

See our guide-book on RULON, Bulletin #9572, in Sweet's Product Design File or send details for recommendations. DIXON CORPORATION, 101 BURNSIDE ST., BRISTOL, R. I.

* DuPont T.M.

DIXON

LITERATURE . . .

Lubricator.....forces oil of any viscosity against the high steam, gas and oil pressure so common in modern compressors, engines & machines. Catalog is available.
171 *Manzel

Mills, Ball & Rod.....in sizes 10′ x 20′. All steel construction for wet or dry grinding systems. Additional information contained in Bul. B2-B20.
152c *Denver Equipment Co.

Mixers.....New Shear-Flow continuous mixers cut processing cost, eliminate costly equipment and offer versatile adaptability. Further information in Bulletin RL-200.
186 *Gabb Special Products, Inc.

Mixers, Laboratory.....Model 4MBH for separate motor drive. Another model is equipped with a direct connected variable speed motor in three horsepower sizes.
63 *The E. T. Oakes Corp.

Process Equipment.....Equipment for efficient and economical cleaning and handling of air and gas. Further information on the products of interest.
177 *Aerotec Industries Inc.

Process Equipment.....“Sub-A” Flotation is available in sizes from 16″ x 16″ to 72″ x 72″. “Cell-to-Cell”, “Free-Flow”, and Type “M”. Bulletin F10-B86.
152f *Denver Equipment Co.

Process Equipment.....Glascote 778 lined vessels speed reaction time. A special resistance rule listing 150 chemicals and the ability of Glascote 778 to resist them.
36 *A. O. Smith Corp.

Processing System.....Hog systems for light or heavy duty work. They reduce rubber tubes, tires, even smoked raw rubber for further processing.
T201 *Mitts & Merrill

Reagent Feeders.....Both wet and dry feeders are available. Many standard units in stock. Complete information on these feeders in Bulletin F6-B8.
152e *Denver Equipment Co.

Reversible Impactor.....features reversible rotation, wide open accessibility and interchangeable impact blocks. Sizes & models for your exact needs. Catalog.
95 *Williams Patent Crusher

Rotary Calciners.....Continuous combination rotary calciners and coolers are ideally suited for processing a wide variety of materials. Details in Bulletin No. 118.
48 *The C. O. Bartlett & Snow Co.

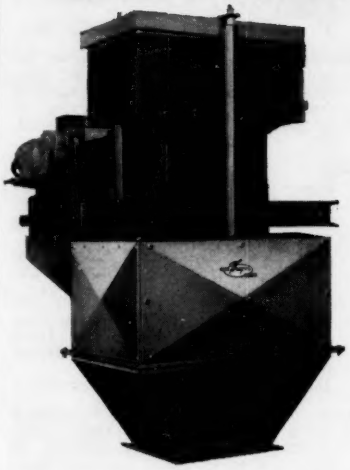
Samplers..... Continuous mechanical & automatic types for dry, solution or slurry sampling. Complete sampling plants & sample processing equipment. Bul. S1-B4.
152j *Denver Equipment Co.

Screens.....for efficient wet or dry screening. “True-Circle” eccentric action. Sizes to 6′ x 14′ in stock. Trommel Screens in sizes from 30″ x 60″ x 120″. Bul. S3-B15.
152k *Denver Equipment Co.

Separators.....for tough separation problems. Liquid vapor separator and wet and dry-type dust scrubbers or gas filters. Details on request.
R175 *Peerless Mfg. Co.

* From advertisement, this issue

STOP PROFIT GIVE-AWAY



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The Thayer Scale has required no maintenance and continues to give “new scale” accuracy in spite of millions of weighings of abrasive rock dusts.

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LITERATURE . . .

Spiral Rake Thickeners....move settled materials to center in one revolution. Acid proof construction available. Further information in Bul. T5-B6.
1521 *Denver Equipment Co.

Pumps, Fans & Compressors

Air Compressor.....Packaged air compressor provides a dependable supply of air for years. No foundation cost, quick & easy installation. Bulletin WB-10 is available.
157 *Gardner-Denver

Compressor, Piston.....Non-lubricated ringless piston compressor assures absolute contamination-free compression of dry or moist gases. Information, specifications.
TL195 *Sulzer Bros. Inc.

Compressors.....A wide variety of designs of compressors in sizes up to 5,000 hp. and for pressures up to 15,000 psig. "Compressor Specifications" booklet.
20-21 *Chicago Pneumatic Tool Co.

Compressors.....F-M Rotary compressors offer no reciprocating parts, no valves, no metal to metal contact. How to step up efficiency and cut down maintenance in Bul. ACO100.4.
10-11 *Fairbanks, Morse Co.

Fire Pumps.....Highly descriptive illustrated 6 page bulletin 401 shows cross section drawings, typical installations, size & capacity charts & advantages.
201A Layne & Bowler, Inc.

Materials Dispensing.....Widest selection of materials dispensing equipment such as measuring valves, pressure primers, hose, couplings, etc. Literature is offered.
57 *Lincoln Engrg. Co.

Pump.....Liqui-Seal unit line ends packing box or mechanical seal failures forever. Pumps all liquids, is always primed, takes minimum floor space. Bulletin.
190 *Johnston Pump Co.

Pump.....Moyno pumps for abrasives, corrosives or suspended solids. Available in nine sizes with capacities for 1/100 to 500 gpm. Bulletin 100-CE is offered.
45 *Robbins & Myers, Inc.

Pump, Vacuum.....The new Series H Microvac pump is designed for compactness. Information about this type plus a Vacuum Slide Calculator are offered.
R210 *F. J. Stokes Corp.

Pump, Vertical Centrifugal.....for handling frothy liquids or coarse, sand slurries, constant or intermittent flow. Capacity to 450 gpm. Bulletin P10-B5.
152h *Denver Equipment Co.

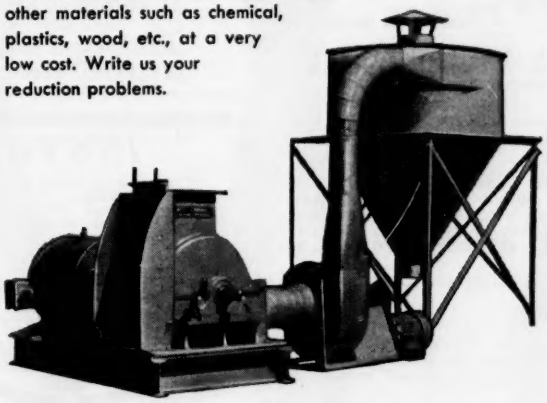
Pumps.....Vari-Flo pumps change capacity instantly. You can dial this pump for thick or thin flow of liquids. Additional information in Bulletin 600.
T199 *Blackmer Pump Co.

Pumps.....to handle viscous or thin liquids, lubricating or non-lubricating liquids, corrosive or noncorrosive liquids. Catalog CC & MC are available on request.
184 *Viking Pump Co.

*From advertisement, this issue

M & M PROCESSING SYSTEM REDUCES ALL TYPES OF RAW MATERIALS

Investigate the advantages of the M & M Hog for your requirements—light or heavy-duty work. Here is why the M & M Hogs are preferred in the chemical industry and by profit-minded engineers—They reduce rubber tubes, tires, even smoked raw rubber, for further processing. In addition, other materials such as chemical, plastics, wood, etc., at a very low cost. Write us your reduction problems.



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Three great series of needle throttling valves—designed and built as only Marsh experience *in both* valves *and* instruments can make them. In materials for extreme range of services. In a full range of sizes and patterns, including panel mounted. For a wide range of pressures and temperatures.

Body and stem guides machined from solid bar stock for extra strength. Precision ground stems with fine pitched stem-threads for close regulation—tight shut-off. Long lived, but easily replaced "Marpak" moulded packing; Teflon in stainless steel valves. Deep inlet and outlet threads for tight make-up.

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LITERATURE . . .

Pumps, Diaphragm.....Stroke can be adjusted while pump is operating. Sizes 1" to 10" simplex and duplex, capacity to 1000 g.p.m. Bulletin P8-B12 offered.
152g *Denver Equipment Co.

Pumps, Proportioning.....Controlled capacity pumps have repetitive metering accuracy of plus or minus 1% when operating between 10% & 100% of capacity.
192 *American Meter Co.

Pumps, SRL (Rubber Lined).....Now available in "TRU-GLANDLESS" construction. No sealing water, no packing glands, no slurry dilution. Additional information in Bul. P9-B28.
152i "Denver Equipment Co.

Rotary Gear Pumps.....Bulletin describes pumps available in capacities from ¼ to 146 gpm at pressures up to 2000 psi and with viscosity handling ability from 300,000 to 30 ssu.
202A Northern Ordnance Inc.

Rotary Pumps.....Gearex pumps are motor or engine driven, skid-mounted or dolly-mounted. Wide range of gear & screw pumps to handle a wide range of materials. Catalogs.
162 *Sier-Bath Gear & Pump

Vacuum Pump.....Complete mechanical and operating details of the Cenco Hyvac S14 mechanical vacuum pump for industrial and laboratory applications are available in 14-page booklet.
202B Central Scientific

Services & Miscellaneous

Casters & Wheels.....All types of rubber treads for smooth operation on all kinds of floors. A new manual is offered describing nearly 4,000 types.
L211 *Darnell Corp.

Chemical Services....Booklet describes various services for equipment cleaning, missile cleaning, waste processes, laboratory services and gives other information.
202C Dow Industrial Service

Cleaner.....Powdered acid cleaner for use in cleaning scale deposits from boilers, heat exchangers, water lines, pumps and other equipment is the subject of bulletin HSP-940.
202D Hagan Chemicals & Controls, Inc.

Control.....Boardmaster visual control is simple to operate and ideal for production, traffic, inventory, scheduling, etc. Further details in booklet BN-10.
BL213 *Graphic Systems

Fire Fighting.....1961 "Interior Fire Fighting Equipment Catalog" provides complete and latest feature information on all lines of companies interior fire safety equipment.
202E The Fyr-Fyter Co.

Laboratory Machines.....Bulletin 067 gives a full description of all laboratory machines. Design provides easy access for cleanouts. Returns complete sample.
R197 *Sturtevant Mill Co.

Wrenches.....New all-wrench tool set cuts maintenance time. Contains 181 pieces. This nut-turning set embodies all the best construction features. Catalog on wrenches.
188 *Snap-On Tools

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Senior chemical engineers, minimum 6 years operating and supervisory experience in alumina production.

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$12,000

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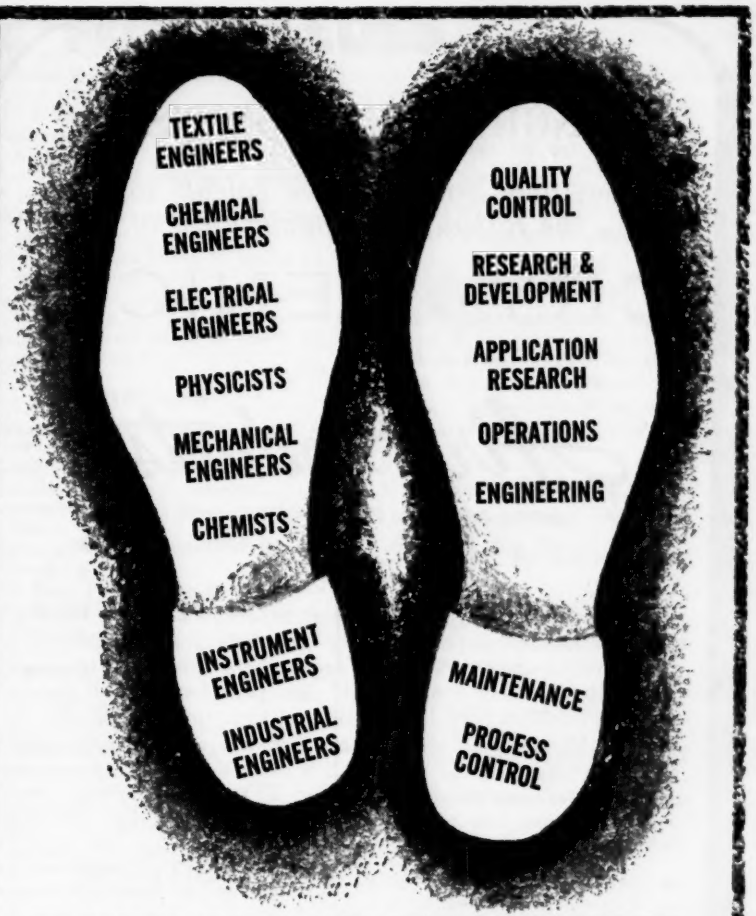

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Unique new conception Parallel Spray Dryer, only 32 ft. high, 1000 lbs. water evap/hr. 100% unbroken heads recovered. Instant-soluble products, foods, vegetable chemicals, soaps. By designer original patented Concurrent Dryer. Best ref. Any solids-containing liquids.
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CIRCLE D ON READER SERVICE CARD

BRILL FOR VALUES

CENTRIFUGES

2—Sharples C-20 and C-27 Super-D-Hydrator, 316 S.S.
1—Bird 18" x 28", Solid Bowl, Continuous, 304 S.S.
2—Bird 24" x 38" Solid Bowl Continuous 304 S.S.
1—Bird 32" x 50", Solid Bowl, Continuous, 316 S.S.
1—Bird 36" x 50", Solid Bowl, Continuous, 347 S.S.
1—Bird 40" x 60" Solid bowl continuous, 316 SS, unused.
3—Sharples PY14, PN14 Super-D-Canters 316 S.S.
2—Fletcher 48" Suspended 316 S.S. Perforated Basket.
2—Sharples #16, 304 S.S., 3 HP motor.

REACTORS—EVAPS—CONDS—TANKS

1—150 gal. 304 S.S. jacketed agitated Reactor.
3—Pfaudler 200 gal. glass lined jacketed Kettles.
1—300 gal. Hastelloy B jacketed Kettle.
1—650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1—550 sq. ft. Buflovak monel single effect Evaporator.
1—500 gal. S.S. Mixing Tank with nickel coils.
6—7500, 6000 and 2000 gal. Rubber Lined Tanks.
2—1000 gal. 304 S.S. Tanks, 5'6" x 6'.
1—1500 gal. Stainless Pressure Tank, 5' x 10', 90#.
1—2,000 gal. horiz. 304 S.S. tank, 5' x 12'.
1—2500 gal. vertical 304 S.S. Tank, 8' x 7'.
1—12,000 gal. horiz. steel Pressure Tank, 7'6" x 36', 200 psi.
6—Stainless Heat Exchangers; 1220, 786, 536, 370, 315, 250 sq. ft.
1—24" dia. x 35', 304 S.S. Bubble Cap Column.

FILTERS

1—#5 Sweetland Filter 304 S.S. 120 sq. ft.
1—Oliver 6' dia. Horizontal Filter, 316 S.S.
1—Oliver 5' x 6' Steel Rotary Vacuum Precoat Filter.
1—U.S. 200 sq. ft. 304 S.S. Auto-Jet Filter.
1—Hercules 400 sq. ft. 304 S.S. Pressure Filter.
1—Oliver 5'3" x 8' Steel Rotary Vacuum, vaporitite housing.
1—Feinc 3' x 3' Stainless Steel Rotary Vacuum Filter.
2—#12 Sweetland Filters, 36 leaves, 4" centers, 500 sq. ft.
1—Feinc 5' x 6' Stainless Steel Rotary Vacuum Filter.
2—#10 Sweetland Filters, 27 leaves, 4" centers, 250 sq. ft.

DRYERS

1—Buflovak Vacuum Shelf with 20—60" x 80" shelves.
2—Buflovak 42" x 120", atmospheric double drum Dryers, complete.
1—Buflovak 32" x 90" Atmos. Twin Drum Dryer.
2—Devine 4' x 9' single drum, atmospheric.
1—Buflovak 3' x 10' Rotary Vacuum Dryer.
1—Baker Perkins 5'6" x 6' Rotary Vacuum Dryer.
1—Buflovak 3' x 7'6" x 7'6" Rotary Vacuum Dryers 316 S.S.
6—Louisville Rotary Steam Tube 5' x 25', 6' x 30', 6' x 50'.
2—Louisville 8' x 50' Stainless Steel lined Rotary Dryers.
9—Rotary Dryers 34" x 30', 4' x 40', 6' x 50', 6' x 60', 7' x 80', 8' x 87'.
1—Traylor 30" x 18' Stainless Steel Rotary Dryer.
2—Link Belt, 7'5" x 25', 6'4" x 24", S.S. Louvre Dryers.
2—Atmos. Tray Dryers, 16 shelves, 40" x 24".
1—P&S 6' wide Apron Conveyor Dryer 48' long.
2—10' and 4' dia. 304 S.S. Spray Dryers.

MIXERS

1—Farrel-Birmingham "Midget" Banbury Mixer.
2—Day Imperial 150 gal. jktd. double arm.
1—Baker Perkins 100 gal. jacketed double, arm, 30 HP.
1—Baker Perkins 50 gal. jacketed, double-arm.
5—Day 'Cincinnatus" double arm, 250 and 100 gal.
2—Steel jacketed Powder Mixers, 225 and 350 cu. ft.
1—Patterson 6' dia. Conical Blender 15 HP.
1—3' dia. Simpson Intensive Mixer.
1—45' dia. Lancaster Mixer 7½ Hp motor.
1—Patterson Kelly 150 cu. ft. Twin Shell Blender.

MISCELLANEOUS

3—Kinney Vacuum Pumps, 750 cfm, 1 micron, 15 HP.
2—Hardinge 5' x 22" steel lined conical Ball Mills.
4—Mikro Pulverizers 4TH, 1 SH, 1 SI and Bantam.
3—Abbe 2½" x 3' porcelain lined Pebble Mill XP motor.
1—Raymond 10" vert. Mill, 10 HP.
1—No. 1 Ball & Jewell Rotary Cutter.
1—#18 Cumberland Rotary Cutter.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
2—#842 Rotex Sifters 60" x 84" double deck.
1—#24 Rotex Sifter, 20" x 64", Quadruple deck.
5—Day Roball Sifters, 40" x 120", 40" x 84", Double Deck.
3—Nash H6 Vacuum Pumps.
4—Stokes Rotary Tablet Machines DD2-DDS2-DS3-RB2.

Partial List of Values—Send for Complete Circular

BRILL EQUIPMENT COMPANY

35-61 JABEZ ST., NEWARK 5, N. J. Tel: MArket 3-7420—N. Y. Tel. RE 2-0820
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CIRCLE E ON READER SERVICE CARD

FILTER PRESSES—6" lead P&F w/pump, 18x18 (26 chamber), 30x30 (11 chamber)

MILLS—Hardinge Conical, 3'x8", 3'x24", 5'x22", 8'x36", 8'x48", 6'x12' rod w/200 HP

VACUUM PUMPS—115 CFM Beach Russ RP w/5 HP motors, Leiman 105 CFM, Dorr Oliver 200 CFM-piston

DRYERS—ROTARY—24"x22', 3'x24', 4'x40' 5'x50', 7'x58', all w/motor drives.

MIXERS—New 3 qt. sigma/jacketed, 5 gal. Bramley 5 HP vac./jack., 12 gal. sigma, 22 cu. ft. ribbon blender.

E. W. LAWLER has stopped piloting International Jet Liners—Full time super service now for YOU.

MIKRO BANTAM w/vari feed drive, 4TH Mikro (unused) w/Mikro collector & 3x5 Tyler screens for closed circuit.

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CIRCLE F ON READER SERVICE CARD

PEP UP YOUR PROFITS!

GET THE MACHINE YOU NEED NOW!

1—Buflovak 42" x 120" vacuum Double Drum Dryer. All access included. Code constructed.

1—36" x 13½' double Ribbon Mixer. Center discharge. 7½ HP motor.

2—Dorrco 60' Thickener Mechanisms, with rakes and motor drives.

1—Nicols Hereshoff Furnace, 8 hearth 13'6" x 17'2" 760 sq. ft.

2—6' x 60' Rotary Dryers. ½" shell. Complete with motor, burner, blower & cyclones.

3—Podbielniak counter current Centrifuges, 316 SS Models 6070 and 9000S.

1—Day 40" x 120" single deck Sifter, mod 81, 2 HP TEFC mtr.

2—Patterson 3' x 4' jcktd Ball Mills. 10 HP Ex prf Mtr.

ME **MACHINERY AND EQUIPMENT COMPANY**
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CIRCLE G ON READER SERVICE CARD

FMC MACHINERY MAGIC

REBUILDS EQUIPMENT TO ITS ORIGINAL FACTORY CONDITION

SPOTLIGHT SPECIALS

J. H. Day 125 Gal. Gearless Pony Mixer; 10 HP. Motor

Raymond Hi-Side Mill 5057 60 HP; with accessories

Buflovak Type 316 Stainless Rotary Vac. Dryer; 3' x 7'6" compl.

Colton Stainless Steel Rotary Granulator;

Mikro 4TH 24" Pulverizer

Kent 3 Roll Lab. Mill 4" x 8"

MIXERS ALL TYPES

Baker Perkins Jktd. 5 gal. UNE-7, Dbl. Arm Mixer with pressure cover; 30 HP.

Readco Jktd. 15 gal. Dbl. Arm Sigma Blde Mixer.

BLAW-KNOX 600 cu. ft. Conical Blender; 9'6" Dia.

Stainless Steel 150 gal. Jktd. Dbl. Arm Mixer with Vac. Cover; Hydr. Tilt.

Other Baker Perkins Jktd. Mixers, 150 gal., 200 and 300 gal.

J. H. Day Cincinnatus Dbl. Arm Mixer; 300 gal. STAINLESS Jacketed.

CONTINUOUS FINE GRINDING EQUIPMENT

To be Sold Direct from Location

2 Allis Chalmers 7'x22' (2 Compartment) Compeb Mills, Meehanite Liners; 400 HP

1 Allis Chalmers 9½ x 810 Preliminator or Continuous Ball Mill; Meehanite Liner magnetic-coupled to 400 HP Motor

3 Allis Chalmers 7'x22' Continuous Ball Tube Mills, Meehanite Liners, each driven by a magnetic coupled 400 H.P. Motor now operating in closed circuit with

3 Raymond 14 Ft. Double Whizzer Mechanical Air Separators, each driven by 75 HP Motor. New in 1950

FIRST'S WEEKLY FEATURE

Save $3000. on This Pfaudler Glass Lined Jacketed Agitated REACTOR; 500 Gal.; 5' x 4'

FIRST COME—FIRST SERVED

Other sizes in Stock

REACTORS—PRESSURE VESSELS

2 Stainless 400 gal. Reactors Jktd. Agtd. by Patterson and Struthers Wells.

6 Dorr-Oliver Stainless Steel Thickeners or Reaction Vessels; 550 gal. 5' x 5'.

Stainless Reactor, 2000 gal. Fully Jktd. Agitated.

Nickel Clad Reactor, 7' x 11'6".

2 MONEL Reactors; 2800 gal. 6'8" x 13'; ASME Jktd. & Intern.

Lancaster Stainless Lined Rotary Reactor or Digester; 50" x 17'4"; Jacketed; good for 300 PSI Internal.

Pfaudler Gl. Lined Reactors; all sizes from 50 to 1000 gal.

Mojonnier Stainless Vac. Pans; 3' x 10' and 6' x 12'; others.

EVAPORATORS—DRYERS

Buflovak S/Steel Thermo-Recompression Evaporator.

Buflovak S/Steel Dbl. Effect Evaporator Model 8½-60 D.

Link Belt Roto Louvre Dryer model 502-20.

Pittsburg Lectro Dryers, Bac 25 and BWC 3400.

Devine Vac. Chamber Dryers, Double Door Model No. 36.

Stainless Lab. Drum Dryer, 8" x 11½".

Bowen S/S Lab. Spray Dryer.

CENTRIFUGES

Stainless Centrifugals from 30" to 60"; A.T.&M. Tolhurst, Fletcher, etc.

Tolhurst 40" Suspended Centrifuges; Rubber Covered Perf. Baskets and Curbs; Monel Plow-Discharge; 7½ HP.

2 Sharples Stainless Steel Model PN14 Super-D-Canters.

4311 S 1 Sharples C 27 Super-D-Hydrator in Type 316 Stainless with 40 HP Motor.

5147 S 13-14 Two Bird Continuous Screen Type Horizontal Centrifuges; Monel & S.S.; 24" x 24".

FIRST MACHINERY CORP.

209-289 TENTH STREET, BROOKLYN 15, N. Y.

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CIRCLE H ON READER SERVICE CARD

LIQUIDATION

OMAHA, NEBRASKA

MAJOR ITEMS

3—1000 KVA trans., 13800—460 v.

5—Buflovak 42" x 120" dbl. drum dryers, ASME 160#

2—Bonnet 7' x 60' rotary dryers,

1—Bonnet 6' x 52' rotary dryer,

9—Davenport #1A #2A dewatering presses, vari-drives

2—French Oil type 2-S screw-type extraction presses 300 PSI, 60 HP.

2—Sweetland #12 pressure filters,

6—Shriver 48" Cast Iron P. & F. filter presses, (50) chambers, hydraulic closure, closed deliv.

2—19,900 sq. ft. quadruple effect calandria type evaporators, copper tubes, cast iron bodies.

5—24" stainless steel screw conveyors, up to 28' long

6—Ansonia 691 sq. ft. dbl. pipe coolers, copper tubes

3—American 654 sq. ft. spiral steel heat exchangers

18—Tubular heat exchangers, copper tubes: 1500, 1350, 1130, 637, 380, 290, 184, 176, 156 sq. ft.

4—Leader Iron 96" dia. steel rectifying columns, 44' & 51' high.

2—9500 gal. horiz. cookers, 9' dia. x 20' long, ½" shell & heads.

10—Forster hammermills, #8 & #6, 100 & 75 HP.

2—Allis-Chalmers Inter-plane grinders, 100 HP

9—Davenport 5' x 25' screens

2—Warren 12" x 12" cent. pumps

250—Steel centrifugal pumps, 1" to 12", 1 HP to 150 HP

2—Aldrich vert. triplex plunger piston-type pumps, steam drive

SEND FOR CIRCULAR #960-A

PERRY EQUIPMENT CORP.
1413-21 N. Sixth St.
Philadelphia 22, Pa.
Phone POplar 3-2505

CIRCLE J ON READER SERVICE CARD

COMPRESSORS

No better values at any price

85 CFM	(Actual) 3500 PSI Clark HO-6-4C
110 CFM	3000 PSI Ing. GC 50BW
138 CFM	100 PSI 7x7, Ing. ES, CP & Joy
288 CFM	100 PSI 9x9 Ing. Worth. CP
294 CFM	125 PSI 9x9 Joy WG-9
311 CFM	1500 PSI 10½-7½-3½-13 IR-ES3
351 CFM	350 PSI 11-5x11 CP TCB-2
465 CFM	100 PSI 12x11-1R-ES CP.T. Worth HB
502 CFM	125 PSI 12x13 Worth HB
593 CFM	110 PSI 13½-8½x8 Worth, DC 2
686 CFM	100 PSI 14x13 Ing. ES
800 CFM	100 PSI 14½-9x7 Ing. XLE
1050 CFM	60 PSI 13-13x12 IR-XRE
1290 CFM	125 PSI 13/8x7 Joy WN114-E
2200 CFM	100 PSI 26-15x18 Ch. Pn. ace 350 HP 3-6-4600 .8 PF
2520 CFM	125 PSI 17-10¾x8 Clark CMA-4L

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE K ON READER SERVICE CARD

PHILADELPHIA—

FIRST STOP FOR SMART EQUIPMENT BUYERS!

JUST PURCHASED

1—Allis-Chalmers 5′ x 5′ ball mill, 75 HP.

1—Fletcher 40″ Susp. Stainless Cent.

5—F. J. Stokes #138-J6 vacuum shelf dryers, 16 shelves 40″ x 44″, 195 sq. ft.

6—Valley 36″ aluminum P. & F. filter presses, 65 chambers, closed delivery, hydraulic closure.

1—Vulcan 60″ dia. x 35 plate T316SS bubble-cap column, 42′ high, Vacuum.

1—Hardinge 8′ x 48″ conical pebble mill, air swept, classifiers.

1—Buflovak 32″ x 52″ double drum dryer, ASME 100# WP.

1—American 42″ x 120″ double drum dryer, ASME, stainless trim.

2—500 gal. T304SS jacketed reactors, ASME, Vacuum, UNUSED.

2—8′ x 56′ rotary kilns, ½″ welded.

4—1350 gal. T347SS jkt. kettles, paddle agit., open top.

2—Bird 24″ x 38″ contin. centrifugals, T304SS cylindrical bowl.

1—4300 gal. T304SS horiz. tank, 6′ dia. x 20′ long, ASME 50# WP.

STAINLESS STEEL TANKS

1—5700 gal., T304SS, horiz., 6′-4″ x 24′, UNUSED.

2—4500 gal., T304SS, 8′ x 12′, UNUSED.

1—4300 gal., T304SS, 6′ x 20′, ASME 50# WP.

1—3700 gal., T304SS, 6′ x 17′, Coils.

1—3400 gal., T304SS, 6′ x 16′, dishd.

1—3300 gal., T304SS, 6′ x 14′, dishd.

1—3200 gal., T304SS, 6-6″ x 12′ coils.

3—2750 gal., T316SS, 7′ x 8′, dished heads, int. coils.

1—2500 gal., T316SS, 7′ x 7′, dishd.

2—2300 gal., T316SS, 7′ x 8′, coils, flat bottom, Agit.

3—2250 gal., T316SS, 7′ x 6′-3″, Agit.

1—2100 gal., T316SS, 6′ x 9′-10″, open top, cone bottom.

1—1750 gal., T304SS, 5′ x 12′, coils.

12—1750 gal., T304SS hoppers, 235 cu. ft.

1—1600 gal., T304SS, 5′ x 11′, dished.

1— 800 gal., T316SS, 5′6″ x 4′6″.

6— 685 gal., T316SS, 3′ x 10′ coils.

1— 600 gal., T304SS, 5′ x 4′, dished.

EVAP. — STILLS COLUMNS — CONDENSERS

7—4050 sq. ft. calandria type evap., copper tubes, cast iron shell & heads.

1—Mojonnier 2085 sq. ft. triple-effect Stainless Sanitary evaporator.

4—Buflovak double-effect stainless evap. vert. long-tube type: 1025, 840, 710, 588 sq. ft.

1—Stokes 118 sq. ft. T316SS U-tube still.

1—Bartlett & Snow 6′ dia. Stainless jkt. evap.-crystallizing kettle.

1—Vulcan 110″ dia. x 16′ high T316SS bubble-cap column, 10 trays.

1—96″ dia. x 44′ high steel beer still.

1—Vulcan 60″ dia. x 42′ high, T316SS bubble-cap column, 35 trays.

1—60″ dia. x 16′ high T316SS bubble-cap column, 10 trays.

1—36″ dia. x 9′-8″ T316SS bubble col.

15—Copper bubble-cap columns, 24″ to 54″ dia., to 51′ high.

1—1960 sq. ft. T316SS exchanger, remov. bundle, ASME 75# WP.

1—1450 sq. ft. T316SS condenser.

5—1400 sq. ft. T316SS gas converters.

3—800 sq. ft. T316SS condensers.

1—730 sq. ft. T316SS exchanger.

6—691 sq. ft. copper Dbl. pipe coolers.

1—510 sq. ft. T316SS condenser.

30—T316SS condensers & exchangers: 427, 425, 410, 400, 290, 277, 264, 250, 200, 185, 165, 150, 145, 105, 83, 73, 54, 52, 50, 47, 30 sq. ft.

12—185 sq. ft. T304SS U-tube coolers.

PRESSES

5—Davenport #1A dewatering presses.

4—Davenport #2A dewatering presses.

2—Davenport #3A dewatering presses.

2—Komarek 160,000 PSI briquette presses.

2—French Oil #2-S screw type extraction presses, 300 PSI, 60 HP.

2—Stokes #DDS-2 rot. tablet presses.

1—Stokes #RD-3 rot. tablet press.

1—Stokes #T single punch press.

FILTERS—CENTRIFUGALS

6—Shriver 48″ C.I. P&F filter presses, 1000 sq. ft., closed delivery

6—Valley 36″ aluminum P&F filter presses, 65 ch., closed delivery.

5—Sweetland #12 filters, (72) stainless leaves, open deliv.

1—Sperry 30″ Ni-Resist P&F filter.

1—Niagara #510-28, T316SS filter.

1—Oliver 5′3″x8′ precoat rotary vacuum filter, UNUSED.

2—Oliver 5′3″x3′ precoat rot. vac. filter, T316SS, ASME 30# WP.

1—48″ Tolhurst susp. cent., T304SS.

5—40″ A.T.&M. susp. cent., T304SS.

2—32″ A.T.&M. susp. cent., T304SS.

1—12″ A.T.&M. susp. cent., T304SS.

30—Sharples #AS-16V super cent., Inconel, vapor-tite, sludge-disch. frame.

2—Sharples #16-P super cent., T304SS, pressure-tite.

2—Sharples #C-20 Super-D-Hydrators, T316SS.

1—Bird 32″x50″ contin. cent., T316SS.

DRYERS

1—Vulcan 10′ x 11′ x 175′ rotary kiln.

2—10 x 78′ rot. dryers, ¾″.

2—Hardinge 8′-8″ x 70″ rotary, ⅜″.

1—Traylor 8′ x 80′ rotary, ⅜″.

2—Davenport 8′ x 60′ rotary, 7/16″ welded, burners, fans, etc.

1—7′-6″ x 62′ rotary kiln, ½″.

2—Bonnet 7′ x 60′ rotary, ⅜″.

1—Bonnet 6′ x 52′ rotary, 5/16″.

1—Louisville 4′-6″ x 25′ steam-tube.

5—Buflovak 42″ x 120″ double drum dryers, ASME 160# WP.

1—Buflovak 42″ x 90″ Dbl. drum.

1—American 36″ x 84″ double drum dryer, ASME, VACUUM.

1—Buflovak 5′ x 12′, single drum dryer, Vacuum UNUSED.

1—Buflovak 6″ x 8″ dbl. drum.

5—Stokes 195 sq. ft. vac. shelf.

2—Buflovak vac. shelf: 110, 98 sq. ft.

1—Bowen Stainless lab. spray dryer.

1—Turbulaire Stainless spray dryer.

1—Nerco-Niro stainless spray dryer.

PERRY EQUIPMENT CORPORATION

1413-21 N. SIXTH ST. PHILADELPHIA 22, PA.

Phone POplar 3-3505

CIRCLE L ON READER SERVICE CARD

LIQUIDATION

at NIAGARA FALLS, N. Y.

Pfaudler 500 gal. Type ELL Glass Lined, jktd., agit. Reactor
4500 and 4000 gal. 316 Stainless Steel Coil Pans
Dopp 1000 & 1700 gal. Ni-Resist Doppley, jktd., agit. Reactors.
Goslin Birmingham 36"x24" Stainless Rotary Vacuum Filter.
Buflovak 6"x8" double drum Rotary Vacuum Dryer.
A.T.&M. 40" & 30" Stainless Susp. Centrifuges, perf. & imperf. Baskets.
Niagara #12 Stainless Steel jacketed Filter.
Buflovak 6' Dia. Crystallizers, atmospheric & Vacuum.
Nash #9, #4, K5 and TS10 Hytor Vacuum Pumps.
Squire 500 Sq.ft . tray truck Dryer.
Str. Wells Electric EH3 Dowtherm Heater

STAINLESS COLUMNS

12"x20' Packed
36"x21' Packed
36"x17'-15 cap trays
48"x40'-40 cap trays
54"x30'-26 cap trays
72"x30'-21 cap trays
78"x18'-14 cap trays

COPPER COLUMNS

24"x 8'-15 cap trays
24"x17'-24 cap trays
30"x11'-12 cap trays
36"x12'-15 cap trays
48"x16'-21 cap trays
48"x25'-35 cap trays
72"x16'-16 cap trays

MISCELLANEOUS

S.S. Condensers 1000 to 68 sq. ft.
S.S. Centrif Pumps 2", 1½", 1"
Norwalk Compressor 15000 PSI
Gear Reducers—Agitators—Blowers
S.S. Valves, Pipe, Tubing

TANKS

STAINLESS TANKS

11000 gal. Horiz. 8'x29'6"
4500 gal. Vert. w/coils
4000 gal. Vert. w/coils
4000 gal. Vert. 7'6"x12'
3500 gal. Vert. w/coils
3500 gal. Vert. 8'x9'
1500 gal. Horiz. 6'x6'9"
1200 gal. 5'x8' Agit
900 gal. 5'x6'
750 gal. 5'x5' Agit
500 gal. 3'6"x8' Agit
500 gal. Vert. w/coils
400 gal. 4'x4' Agit.
300 gal. 4'x3' Cone bot
150 gal. 3'x3' Agit.

GLASS LINED

2000 gal. Horiz. 6'x10'
1000 gal. Vert. Agit.
900 gal. Horiz. 5'x5'6"

ALUMINUM TANKS

12000 gal. Horiz. 10'x23'
10000 gal. Horiz. 9'x23'
7000 gal. Vert. 10'x12'

COPPER TANKS

3500 gal. 8'x9' w/coils
2000 gal. 7'x7' w/coils
500 gal. 4'x5' w/coils

STEEL TANKS

22000 gal. Vert. 12'x25'
11000 gal. Horiz. 8'x30'
8500 gal. Vert. 8'x22'
5000 to 250 gal. (50)

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Filter: Eimco, drum 16" x 12".
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1—Robinson stainless steel 125 cu. ft. horizontal double ribbon blender
1—Raymond 2 roll high side roller mill
1—Oliver SS rotary vacuum pressure precoat filter, 5'3" x 8'

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2—Blaw Knox 600 gal. steel reactors, complete with double motion agitators and drives, 50# jacket, 50# internal
1—Steel 1200 gal. vertical pressure tank, 150 psi
3—Theo. Walters 300 gal. Hastelloy B jacketed reactors
1—Van Alst 300 gal. stainless steel jacketed kettle
1—Blaw Knox 300 gal. stainless steel vacuum reactor
1—Pfaudler Series EL 750 gal. glass lined jacketed reactor, 90# working pressure jacket, complete with impeller type agitator, baffle and drive
1—Pfaudler 30 gal. Series P, jacketed reactor, complete with impeller type agitator, baffle and drive
1—Struthers Wells type 316 SS jacketed reactor 2000 gal. complete with agitator and drive

DRYERS

2—Bonnet rotary kilns, 8' x 115', complete
1—Bonnet rotary cooler, 8' x 50', complete
1—Allis Chalmers stainless steel rotary dryer, 6' x 50', complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louver dryers, Model 207-10, 310-16, 604-20
2—Buflovak stainless steel rotary vacuum dryers, 5' x 30'
1—Buflovak SS jacketed rotary vacuum dryer, 3' x 15'
2—Stokes SS jacketed rotary vacuum dryers, 3' x 15' and 2' x 6'
1—American 42" x 120" double drum dryer, ASME, N. B. constructed, complete with drives and motors
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Western Precipitation Corp. SS pilot plant spray dryer, Type N-2
1—Bowen Stainless Steel pilot plant spray dryer
1—Stokes single door vacuum shelf dryer with 6 shelves, 24" x 36"

FILTERS

12—Sweetland #12 filters with 72 stainless steel leaves
1—Niagara stainless steel filter, Model 510-28
1—Oliver horizontal filter, 3'
1—Oliver stainless steel rotary vacuum filter, 3' x 4'
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers
10—Shriver plate and frame filter presses 12" to 42"

CENTRIFUGES

1—AT&M 48" stainless steel, suspended type centrifuge, complete with plow, motor and imperforate basket
1—Fletcher 48" stainless steel, underdriven centrifuge, complete with perforate basket and motor
7—Western States 40" type 316 SS, suspended type centrifuges, complete with perforate baskets, plows and 40 HP motors

THE GELB GIRL—MARCH 1961

1AT&M 26 type 316 SS, suspended type centrifuge, complete with perforate basket, plow and motor
4—Tolhurst 40" center slung rubber covered centrifuges, complete with perforate baskets and motors
1—Tolhurst 30" center slung rubber covered centrifuge, with perforate basket and motor

MIXERS

2—Sturtevant #7 dustite rotary batch blenders, NEW
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Baker Perkins, Size 16, Type UUEM, 150 gal. jacketed double arm dipersion type mixer, complete with compression cover and 100 HP motor
1—Stokes stainless steel granulating mixer, Model 21-J
1—Colton stainless steel granulator, Model 561-S

MISCELLANEOUS

1—Stewart Bolling 2 roll chrome plated, plastic mill, 8" x 16"
1—Ross 6" x 14", 3 roll paint mill, high speed, complete
1—Vulcan stainless steel bubble cap column, 4' x 25 plates
1—Badger type 316 SS bubble cap column, 42" diam. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 and 600 sq. ft.
1—Downington type 316 SS heat exchanger, 750 sq. ft.
1—Griscom Russell stainless steel heat exchanger, 900 sq. ft.
4—Patterson type 316 SS condensers, 200 and 300 sq. ft.
20—Davis Engineering stainless steel heat exchangers, 102, 119, 136, 166 sq. ft. NEW
4—Davis Engineering Carpenter 20 heat exchangers, 125 sq. ft., NEW
2—Swenson type 316 SS vacuum crystallizers, 3'6" x 12' and 2' x 12'
3—Mikro #1SH pulverizers, complete
1—Mikro #2TH pulverizers, complete
2—Mikro #3TH stainless steel pulverizers, complete with 40 HP motors

1—J. H. Day SS double arm sigma blade, vacuum jacketed mixer, 5 gal.
1—Hersey stainless steel rotary dryer, 3' x 20'
1—Alloy Fabricators SS jacketed reactor, 400 gal., complete with turbine agitator and Mixco drive
1—Pfaudler Series EM 300 gal. glass lined jacketed reactor, complete with anchor type agitator and drive

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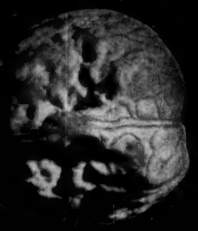

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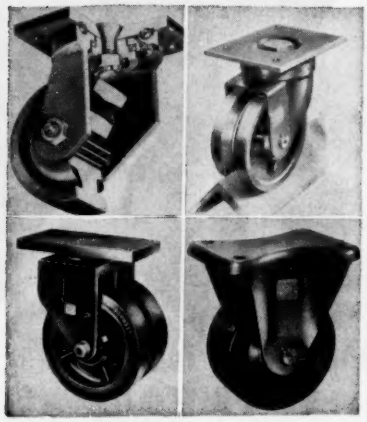

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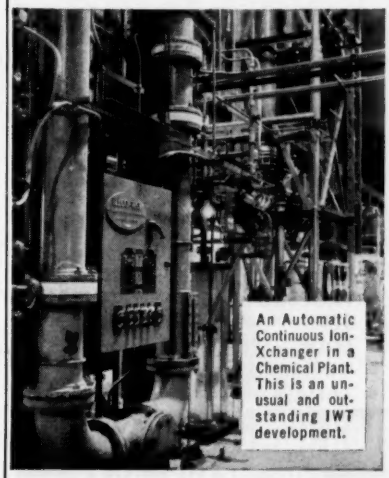

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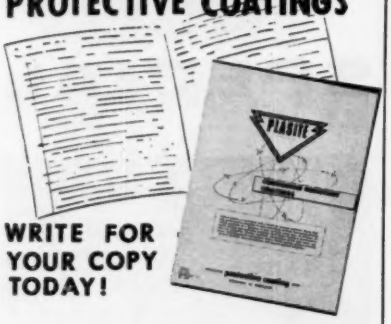

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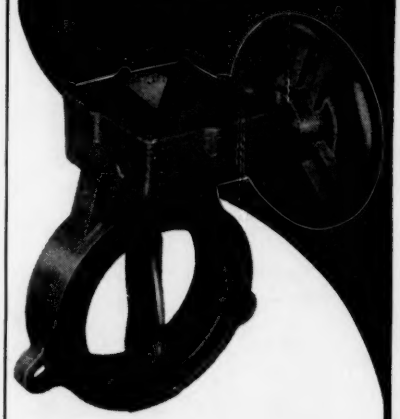

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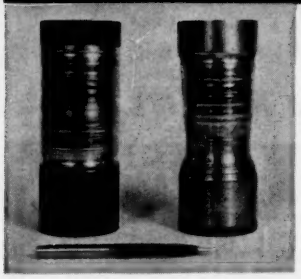

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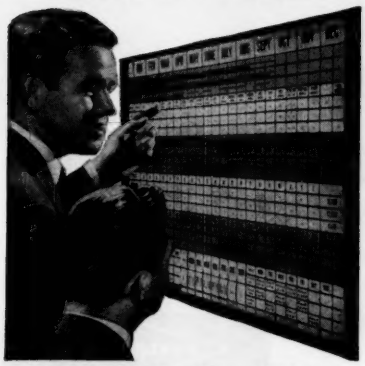

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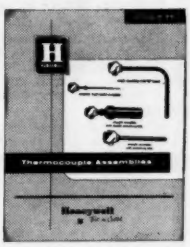

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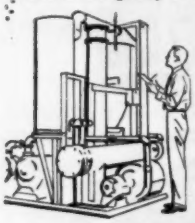

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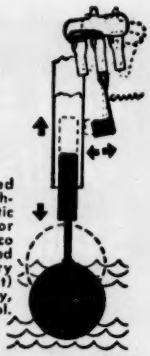
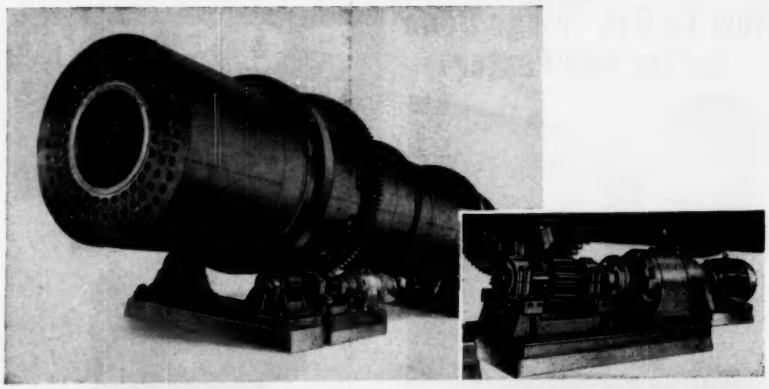


A sleeve, raised and lowered within a nonmagnetic tube, attracts or releases an Alnico magnet attached to the mercury (or dry contact) switch. Basically, this is Magnetrol.

The operating principle behind MAGNETROL LIQUID LEVEL CONTROL

Because its operating principle, based on the proper use of a permanent magnet, guarantees a perpetual guardianship over your critical liquid levels, the Magnetrol liquid level control unobtrusively takes the most important place in any system or process where it is necessary to keep a liquid at a constant level. Principle and action are so simple that failure is virtually impossible. Magnetrol is versatile, too—will handle almost ANY liquid, at ANY temperature, at ANY pressure, with the same precision and dependability. No mechanical or electrical linkages to stick, bind, ride out of line or wear out. Available for controlling level changes from ½" to 150 ft. Multi-stage switching when desired. Write to

MAGNETROL, Inc., 5324 Belmont Road, Downers Grove, Ill.



"DAVENPORT" Rotary Steam Tube Dryer 8'-0" x 45'-0"

Efficient contact drying of many products is required in industry today. "DAVENPORT" Rotary Steam Tube Dryers have been performing this service with unmatched efficiency, accuracy and cost.

Let our engineers consult with you on your Pressing, Drying and Cooling problems or send for our catalog, "A". For quick reference consult your Chemical Engineering Catalog.

DAVENPORT MACHINE AND Foundry Company
A DIVISION OF MIDDLE STATES CORPORATION
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PRESSING — DRYING and COOLING Equipment

Continuous DeWatering Presses

ROTARY DRYERS
Steam Tube, Hot Air and Direct Fire

Atmospheric DRUM DRYERS

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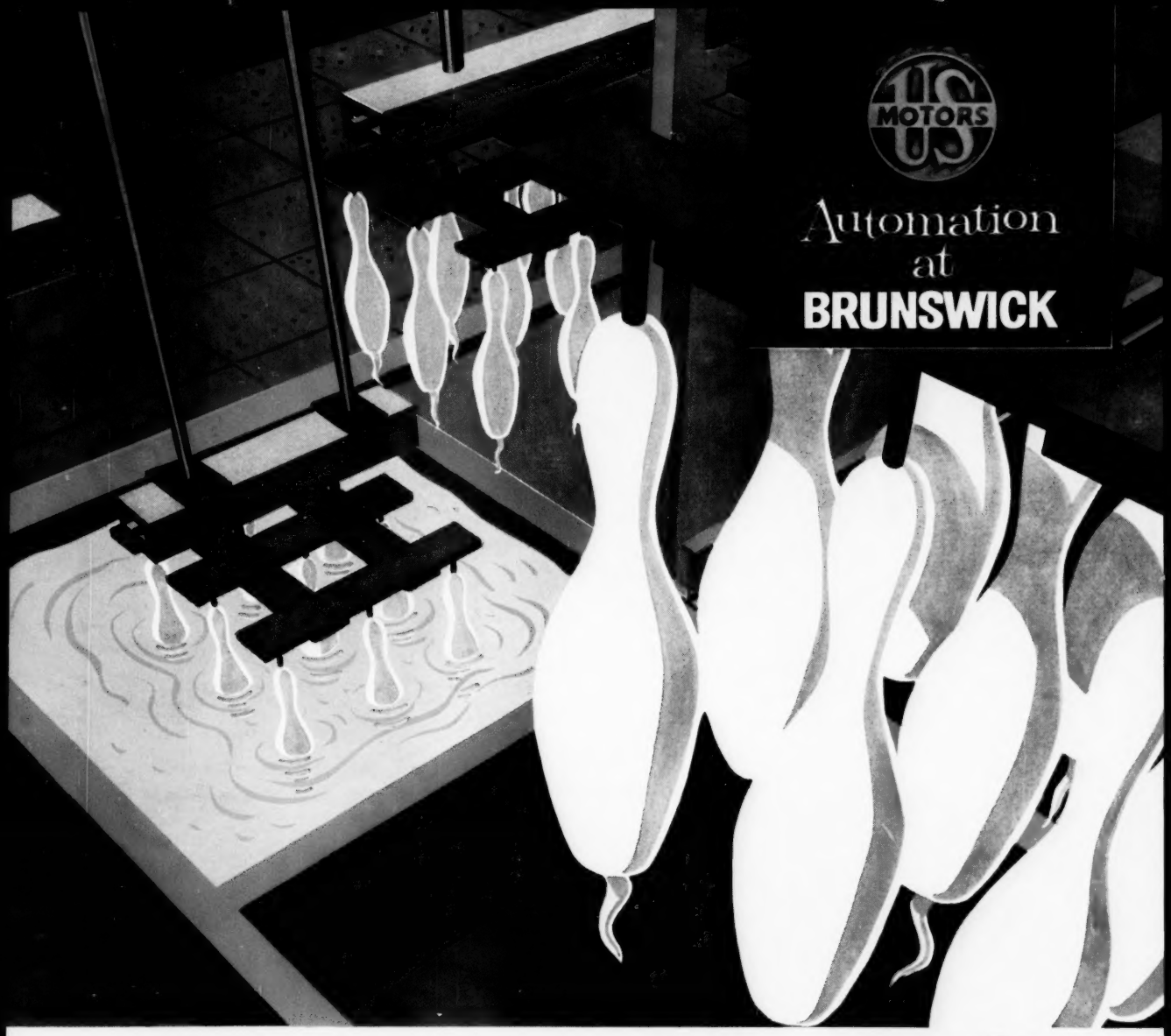
Water and Air



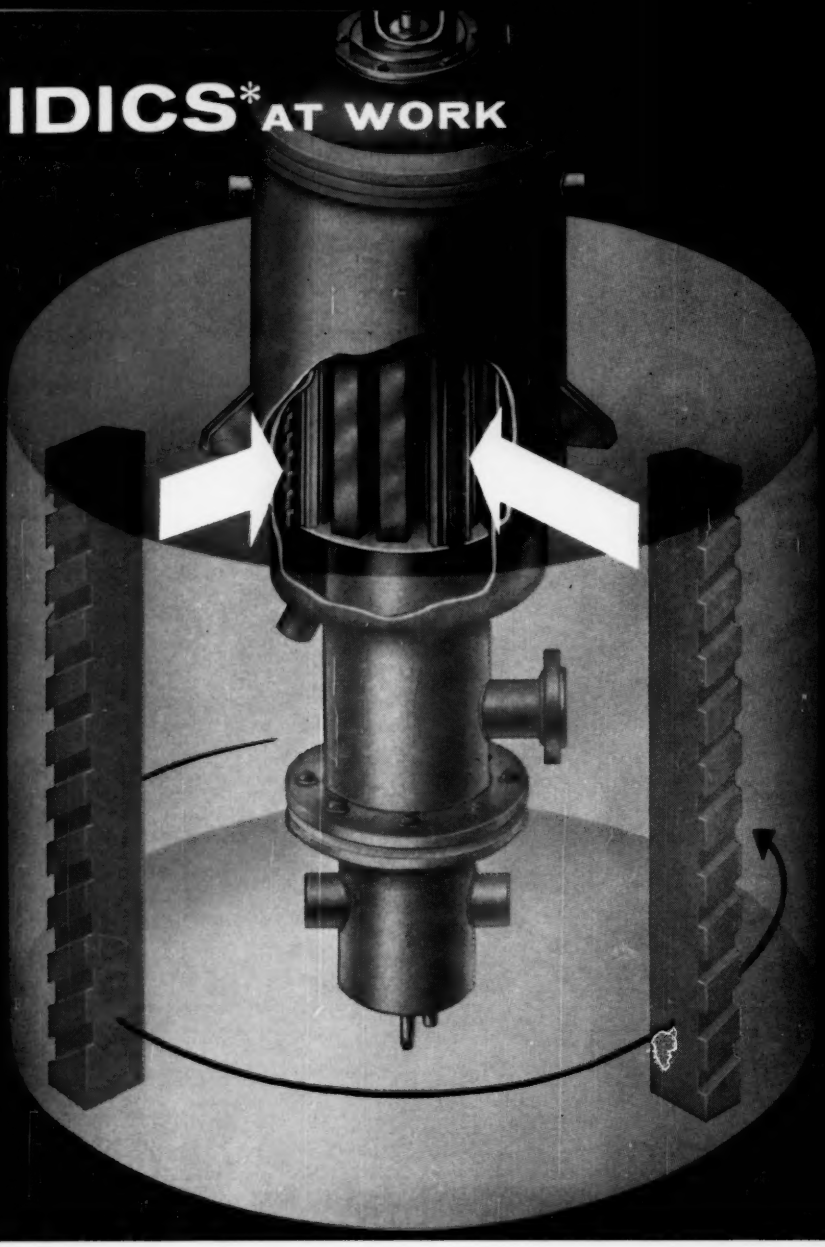
U.S. VARIDYNE system synchronizes conveyors for point-to-point pin transfer

Problem: Brunswick's "Dura-King" pin required multiple dips in liquid plastic to achieve its high impact-resistant plastic coating. Resultant highly explosive atmospheres required *explosion-proof* production methods. In addition, accurate synchronization for point to point transfer between *five* variable speed, multimotor conveyors was required. **Solution:** U.S. VARIDYNE a/c Drive System with *Coordinated Start and Stop Control,* and U.S. Explosion-Proof A.C. Motors. Richards-Wilcox engineers, working with Brunswick Corp. engineers and U.S. MOTORS field engineers, chose VARIDYNE over a d.c. system because: initial start-up is simplified; instantly synchronous without warm-up; needs no synchronizing readjustments; there is no cumulative error; and *explosion-proof a.c. motors* can be used. VARIDYNE varies the frequency of a.c. current to these motors, converting them to adjustable speeds... automatically coordinated. *Write today for* VARIDYNE *Brochure F-1963.*

U.S. ELECTRICAL MOTORS INC.

P. O. Box 2058 • Los Angeles 54, California or Milford, Conn.

FLUIDICS* AT WORK



FACT: These slotted wipers wet the entire evaporator wall with a uniform, thin film.

RESULT: You get high thermal efficiency and excellent heat transfer when evaporating products that are heat-sensitive, highly viscous, or low in thermal conductivity.

In the Pfaudler® Wiped Film Evaporator you'll find four of these wipers.

They are free-floating and held in contact with the evaporator wall by centrifugal force. The slots in the wipers *prevent* product curl and help accelerate movement down and off the wall.

This gives you the best combination for full utilization of heat transfer area, an *ultra-thin* film for highest "U" values, and very short contact time at elevated temperatures.

The Pfaudler Wiped Film Evaporator is a high-capacity production unit that can provide you with an evaporation rate of up to 50 lbs per hr per ft² of heat transfer area, depending on the product. For water and light solvents, the "U" values range up to 400 BTU per (hr) (ft²) (°F).

You can choose from models with 12″ I.D. (4, 9 or 12 sq ft of evaporating area) or 36″ I.D. (30, 50, 75 and 100 sq ft). If your needs call for larger sizes, we can fabricate them on a custom basis.

Offer: We'll gladly test your product in the Wiped Film Evaporator maintained at the Pfaudler Test Center. We'll answer any questions you have. Or, you can study more details as spelled out in our Bulletin 991. Write to our Pfaudler Division, Dept. CEB-31, Rochester 3, N.Y.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes